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NAME OF AUTHOR/*NOM DE L'AUTEUR* LEENDERT P. MOS

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DATED/*DATÉ* Sept 11 / 1974 SIGNED/*SIGNÉ* Leendert Mos

PERMANENT ADDRESS/*RÉSIDENCE FIXÉ* 4812 - 116 St
Edmonton, Alberta, Canada

NL-91 (11-73)

THE UNIVERSITY OF ALBERTA

CONCEPTUAL ABSTRACTION:
A THEORETICAL AND EXPERIMENTAL STUDY OF THE ACQUISITION OF MEANING

by

© LEENDERT P. MOS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled, "Conceptual Abstraction: A Theoretical and Experimental Study of the Acquisition of Meaning" submitted by Leendert P. Mos in partial fulfillment of the requirements for the degree of Doctor of Philosophy ~~in~~ Psychology.

Kellogg Wilson
Supervisor

Wm J. Baker

C. Brainerd

Bruce L. Dewing

Robt A. Shaw
External Examiner

Date July 9th 1974

ABSTRACT

This dissertation consists of two parts. The first part, composed of six chapters, presents a theoretical investigation on the relation between language and thought. The second part, composed of three chapters, presents an experimental investigation of the phenomenon of idea acquisition and retention. These studies are not intended as a strict verification of the correctness of the propositions presented in the theoretical chapters. Rather, the theoretical proposals have wide ranging import and the intent of the experimental research is to set up appropriate conditions under which a part of this knowledge can be exemplified in experience. Hence, the correctness of the theoretical propositions is not established by the ensuing research. The latter constitutes a paradigmatic investigation which is judged congruent with the previous proposals and provides observational evidence for them.

After some general introductory remarks on the problems to be dealt with in subsequent chapters, Chapter 2 contrasts the adequacy of a functionalist-behavioristic with a causal-structural explanation of behavior. In Chapter 3, the notion of psychological competence as proposed within linguistic theory is examined as a causal-structural explanation of language. Chapter 4 reviews the recent transition from a focus on syntactic to one on semantic variables within the discipline of linguistics and maintains that this shift is one entirely appropriate to the formulation of a psychological theory of meaning. Chapter 5 attempts to make explicit some of the implications of a causal-structural explanation of meaning with reference to a theory of *conceptual*

abstraction. Finally, Chapter 6 probes some of the formal requirements of an organism capable of conceptual abstraction with references to scientific realism.

Part 2 consists of three chapters. Chapter 7 documents the relevant experimental literature in psychology with respect to the problem of the abstraction of meaning. It notes that persons do not simply retain the information expressed by individual semantic or pictorial events; rather, they spontaneously integrate information communicated by sets of semantically related events, whether as sentences or pictures, into wholistic abstract representations which encompass more information than any single particular previously experienced event. Subsequent recognition memory is a function of these abstract conceptual structures. Persons will recognize events never previously presented which are consonant with the abstract structures and be able to distinguish these from events at variance with these structures. Chapter 8 experimentally demonstrates the phenomenon of idea acquisition and retention in four separate studies. The results are discussed in Chapter 9 and it is concluded that persons spontaneously integrate information conveyed by non-consecutively experienced but related events into wholistic abstract structures where these contain more information than any single acquisition event.

PREFACE

. . . I ceased to be a baby unable to talk, and was now a boy with the power of speech. It was not my elders who showed me the words of some set system of instruction, in the way that they taught me to read not long afterwards; but instead I taught myself by using the intelligence which you, my God, gave to me. For when I tried to express my meaning by crying out and making various sounds and movements, so that my wishes should be obeyed, I found that I could not convey all that I meant or make myself understood . . . So my memory prompted me. I noted that people would name some object and then turn toward whatever it was that they had named. I watched then and understood that the sound they made when they wanted to indicate that particular thing was the name which they gave to it, and their actions clearly showed what they meant, for there is a kind of universal language, consisting of expressions of the face and eyes, gestures and tones of voice which can show whether a person means to ask for something . . . . So, by hearing words arranged in various phrases and constantly repeated, I gradually pieced together what they stood for, and when my tongue had mastered pronunciation, I began to express my wishes by means of them.

St. Augustine
Confessions Book I, (8)

As a baby of course, I knew no Latin either, but I learned it without fear or fret, simply by keeping my ears open while my nurses fondled me everyone laughed and played happily with me. I learned it without being forced by threats of punishment, because it was my own wish to be able to give expression to my thoughts. I could never have done this if I had not learned a few words, not from my school masters, but from people who spoke with me and listened when I delivered to their ears whatever thought I conceived.

St. Augustine
Confessions Book I, (14)

Someone coming into a strange country will sometimes learn the language of the inhabitants from ostensive definitions that they give him; and he will often have to guess the meaning of these definitions; and will guess sometimes right, sometimes wrong.

And now, I think, we can say: Augustine describes the learning of human languages as if the child came into a strange country and did not understand the language of the country; that is, as if it already had a language, not only this one. Or again; as if the child could already think, only not yet speak. And 'think' would here mean something like 'talk to itself'.

Wittgenstein
Philosophical
Investigations 32

How should we explain to someone what a game is? I imagine that one should describe games to him, and we might add: "This and similar things are called 'games'". And do we know anymore about it ourselves? Is it only other people whom we cannot tell exactly what a game is? - But his is not ignorance. We do not know the boundaries because none have been drawn. To repeat, we can draw a boundary - for a specific purpose. Does it take that to make the concept usable? Not at all! (Except for special purposes.) No more than it took the definition: 1 pace = 75 cm. to make the measure of length 'one pace' usable. And if you still want to say "But still, before that it wasn't an exact measure", then I reply: very well, it was an inexact one. - Though you still owe us a definition of exactness.

Wittgenstein
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CHAPTER 1

INTRODUCTION

It is reasonable to assume, as common sense does, that some linguistic and some cognitive phenomena are convergently related at the phenomenological level. For what language typically does is to convey or elicit cognitive meaning. One way in which this assumption has been acted upon is exemplified in the attempts to integrate linguistic and psychological concepts at the theoretical level. Nevertheless, there is every reason to suppose that some thinking is non-linguistic, and conversely, that some talking occurs without the dictates of some inner voice prescribing intelligent speech. Indeed, the problem of the relation between language and thought may be conceived of as belonging to a class of problems about cognition that has no necessary relation to natural language. Thus, ambiguity, homonymity, synonymity, paraphrase, translation, and still other phenomena convincingly demonstrate that the meaning of a linguistic expression cannot be the same as, or an internal sensory correlate of, the articulatory word vehicle. Man's routine ability to interpret information from one mode in terms of information from another provides additional support for the notion that the 'language' which permits the 'translation' of information from the various modalities cannot be the language of any one mode, but must in some sense contain them all. An ideational or conceptual language must be sufficiently rich to represent information from the various modalities and sufficiently flexible to permit retrieval of information in these various modes when required. On this account natural language is analogous to a highly specialized channel which has access, whether via the primary auditory or derived visual mode, to this conceptual language.

Information elicited by natural language, like all other sensory information, is subject to integration and interpretation in the light of available information in memory and other current experience. The comprehension and production of speech involves translating between this conceptual language and natural language.

There is considerable evidence, both phenomenological and experimental, for the distinction between a conceptual language and a natural language. Thus, the felt inadequacy of successive attempts to express one's thought verbally suggests that the former is available, at least in rudimentary form, prior to its linguistic coding. More generally, it is difficult to understand the asymmetry between comprehension and production of language in the child, or how a society could expand its cognitive limits, if experience and thought were restricted to the linguistic resources available at any given ontogenetic or historic period. Similarly, the introspective evidence that thought is available as images would appear to preclude that the former is strictly linguistic. Furthermore, the observation that information about form and source is lost much more quickly than information about content, may be expected, provided that this conceptual language is relatively neutral between the various modal codes. Experimental evidence that the 'language' of cognitive meaning is not inherently tied to linguistic form comes from the literature on aphasias and linguistic deficiency in deaf persons. Finally the fact that something like cognition is evident in some infrahuman organisms which do not display anything like a genuine language, would force the conclusion that the 'language' of cognition need not be natural language. All this does not deny that in the adult person, thinking may be linguistic and indeed both philosophical and psychological considerations of meaning have traditionally adhered to an account of either meaning-as-language or meaning-as-imagery.

The problems of characterizing the exchange between a conceptual language and natural language is well beyond the present state of the discipline and hence beyond the scope of this paper. At the same time it is clear that any such attempt must confront classic theoretic issues. First, what is the nature or organization of such a conceptual language which permits the acquisition, retention and retrieval of knowledge? This immediately raises the question of the status of 'ideas' and 'concepts' and just as readily skirts the traditionally mirky epistemological question of nominalism and realism. More recently, within the the context of psychology this issue has been dealt with in terms of the organization or the structure of memory which permits the acquisition and retrieval of cognitive meaning, or more inclusively, the problem of the nature of 'cognitive representation'.

Second, what are the constraints on such a conceptual language which permits its expression in any natural language, or conversely, what must a natural language be that one can learn to use it? This question involves examination of the traditional linguistic concepts of 'composition' (form) and 'correlation' (meaning), the two planes on which a natural language may be described. Contemporary linguistic theory has concerned itself primarily with the former in terms of the distinction between the formal aspect of language exemplified by rules and the substantive aspect of language in terms of elements or classes of elements to which reference is made by these rules. Again, this topic has been discussed more generally under the heading of 'competence' theory and assigned to the empirical domain of psychology.

Third, what is the nature of the acquisition of cognitive meaning and secondarily, this meaning embodied in natural language? This question is intimately tied to the first and confronts the adequacy of the theories of the concept and the principles of their acquisition. Contemporary theory in psychology and linguistics has been critical of the subtractive theory of abstraction with respect to concepts and the principles of association with respect to their acquisition. Instead both transformational generative grammar (TGG) and structural learning theory have proposed the explanatory primacy of abstract entities causally related to experience and behavior by a generative set of principles or rules. This is exemplified by the deep-surface structure distinction proposed in linguistics and the conceptual dependency or relational structure of memory proposed in psychology.

The present thesis consists of two parts. Part 1 is a schematic presentation of some proposals for the structure of human knowledge systems and is composed of six chapters. Chapter 1 contrasts the adequacy of a functionalist-behavioristic with a causal-structural explanation of behavior. Chapter 2 exemplifies how linguistic theory with its focus on the notion of psychological competence adheres to such a causal-structural explanation of language. Chapter 3 examines the transition from a focus on syntactic to one of semantic variables within linguistic theory, and notes that this shift is one entirely natural to a psychological theory of meaning. Chapter 4 attempts to make concrete some of the implications of a causal-structural explanation of meaning for a theory of conceptual abstraction. Chapter 5 explores in some detail the requirements of a mechanism capable of conceptual abstraction. Finally, Chapter 6 documents the relevant experimental literature in psychology which has addressed itself to these same issues.

Part 2 presents four experiments which are intended to demonstrate the validity of only certain of the claims made in Part 1. These studies deal with the acquisition of meaning and replicate and extend a number of previous findings. Chapter 7 provides the method, procedure and results of these four studies, and Chapter 8 states the conclusions.

CHAPTER 2

A FUNCTIONALIST-BEHAVIORISTIC VERSUS CAUSAL-STRUCTURAL EXPLANATION OF BEHAVIOR

Systematic explanations of behavior and behavior capacities consist of demonstrating what the organism does is determined in some complicated way by features of the environment on the one hand, and by mental states, processes, and events on the other (Bergmann, 1952; Fodor, 1968; Spence, 1948). Functional explanations of behavior typically include mediational constructs with a view toward fitting more precisely the exact form of behavior. However, the functionalist-behaviorist tradition has been decidedly peripheralistic in its theory construction and has accepted stimuli and responses, and their mediational equivalents, as conventionally defined often in terms of ordinary language. That is, knowledge of stimuli and responses is intuitively accepted and what is perhaps less obvious, defined in terms rather than propositions (O'Neil, 1953, 1958; Rozeboom, 1960, 1961a). The precarious problems of stimulus and response equivalence are dealt with in terms of a rigorous methodology which permits the causal interpretation of functional dependencies (Nagel, 1961). Thus the assumption is made that events which appear similar to us will appear so to others despite the fact that these events have nothing in common except the fact that they are treated as similar or different by the mind of one. In short, the objectification of observation has become equated with reliability where the latter appears not to require explanation. That is, the nature of scientific explanation of behavior has been primarily 'phenomenological' rather than 'theoretic' (Bunge, 1963, 1967), or 'representational' (Pylyshyn, 1973a).

The functionalist-behaviorist tradition may be criticized, in principle, for failing to formally account for the structure of knowledge. In fact, the historic development of the discipline, which evolved through a peripheralist period to deal with more complex human behavior in more extended circumstances, has made it extremely difficult to adequately specify meaningful stimulus and response units. Thus Chomsky, in his review of Skinner's *Verbal Behavior*, criticizes the latter for his unjustified metaphorical extension of laboratory language and findings to natural language acquisition. Skinner in doing so assumed all the problems that Chomsky thought required explanation. In effect, Skinner and Chomsky were not concerned with the best account of the same data, but rather, with the type of problems that demanded explanation in any account of language acquisition. Chomsky's claim, in short, was that the explanation of language use required an explicit structural description of the articulatory event, of one's 'knowledge' of the event, prior to a determination of its function in communication.

What emerged from this review (Chomsky, 1959), and from the cybernetic hypothesis since the early forties (Ashby, 1956; Craik, 1943; George, 1962; Wiener, 1948) is that any explanation of complex behavior assumes an explicit structural description of stimuli and responses, which not only supplements one's intuitions about these events, but explains one's knowledge of these events and the laws that govern them. Such an explanation presumably provides for an understanding not only that the law holds, but why it does hold (Rozeboom, 1961b; Sellars, 1961). A 'mechanistic explanation' (Turner, 1971) requires an explicit structural analysis of stimulus and response units and the hypothetical construction or synthesis of a mechanism which is capable of performing the mapping function of stimulus to response. Such a formal mechanistic explanation takes the view that "the structure of the machine or of the organism is an index of the performance that may be expected from it" (Wiener, 1950). A mechanistic explanation which is achieved by means of such an analysis and synthesis procedure may be termed a 'generative' explanation (Shaw & Halwes, 1966; Shaw, Halwes & Jenkins, 1966). That is, one which moves beyond the mere analytic solution to the understanding of behavior, the establishment of functional relations, to the problem of synthesizing the mapping function. That is, generative explanations involve the construction of computational or cybernetic models of behavior which, in principle, possess the capacity for producing the behavior. Generative explanations provide more than descriptive and predictive knowledge, these explanations entail a causal theory of the mechanism of behavior which is not directly observable (Pask, 1969). At the same time it must be emphasized that such explanations are not another version of empirical construct theory, for mediational constructs postulated by advanced behaviorese, themselves require an explicit structural description. What is desired of a rationalistic synthesis of natural phenomena, one that moves beyond phenomenology and verification of specific behavior, is that the behavior of the formal model postulated by the generative theory be identical to that of the behaver being modelled. Since generative mechanisms are theories of the behaver rather than of behavior, the transituational application of the explanatory model is plausible. The structural viewpoint is essentially one that attempts to characterize formally (or materially) what the person knows which accounts for the regularities described in a functional analysis. In a sense, of course, all mediating constructs, words, images, and meaning responses make certain existential claims, but with the difference that their introduction into theory is with the aim towards more adequate specification of stimulus and response dependencies (Spence, 1948).

It must be understood that while the functionalist-behaviorist tradition has contributed very little to our understanding of structure, this has not been due so much to its functionalism as to its adherence to a peripheralistic behaviorism. The former developed quite independently of behaviorism. It was behaviorism that uncritically accepted structure as implicit in its basic units of analysis. However, as the latter has historically become less of a philosophic doctrine and more of a methodological imperative, we also find a gradual concern with the structure of behavior as witnessed in the transition of titles from B. F. Skinner's *The Behavior of Organisms* (1938), D. O. Hebb's, *The Organization of behavior*, (1949) and Miller, Galanter & Pribram's *Plans and the structure of behavior* (1960). As previously remarked, this trend may have been anticipated, however it has been greatly accelerated by cybernetic theorizing, and its concern with information processing (Neisser, 1967), the computer simulation of psychological processes (Reitman, 1965), and the application of automata theory, or formal machines. The latter has seen application in the work of Noam Chomsky (Chomsky, 1956; Chomsky & Miller, 1963) whose TGG has been most influential in the psychology of language (Dixon & Horton, 1968; Jakobovits & Miron, 1967). These developments have this much in common that not only do they reject peripheralistic strictures of behaviorism including the adequacy of mediational accounts (Bever, Fodor & Garrett, 1968; Fodor, 1965), but they maintain that the effect an event has on behavior depends first and foremost on how that event is represented within the organism and that any explanation requires an explicit account of this representation. A theory of competence refers to such a representation and is not only concerned with behavior *per se*, rather, with how information about the world is represented in a person's mind which makes it possible for him to perform the way he does or the way he could perform under a variety of conceivable circumstances. It reflects the belief that in order to say something important about how people behave, "... it is first necessary to understand what the distinctions are that are contained in people's mental representations of their perceptual and behavioral world" (Pylyshyn, 1972, p. 548).

It is apparent, for example, that one can distinguish between intuitive knowledge which is available through introspection and experiment from that which is necessary and sufficient, but which is not so available. Such a distinction is drawn with respect to human knowledge of logical operations by Beth & Piaget (1966). That which is available in perception or upon introspection, and presumably psychologically real, these authors term "psychological" knowledge, whereas that which is necessary for an adequate description of this knowledge they term "epistemological" (Beth & Piaget, 1966, p. 149 ff.). The authors state that the object of psychological study is not firstly behavior but rather "conduct" and that the latter includes "awareness" and the study of conditions that determine "becoming aware." The process of becoming aware may offer specially useful opportunities for introspection (cf. Pylyshyn, 1973b). Secondarily, these authors claim that insofar as logical structures are concerned, we must suppose that since the person "constructs" them, they are in a sense "in him" and that at some point the person can become aware of them (in using them) "... *as if* he discovered them" (Wales, 1969, p. 446).

The various degrees of awareness usually preclude normal report of these logical structures and it is in fact only the investigator who will eventually attempt to give an explicit description of these structures. The distinction between "sujet psychologique" and "sujet epistémique" (Beth & Piaget, 1966), rests on (a) potential for "awareness", and (b) the role that these two "metaphorical homunculi" play. Thus, "sujet psychologique" has a functional role, whereas "sujet epistémique" has a constructive role as the causal source of cognition (cognition structures). However, the latter, insofar as it is the source of cognition, must also have psychological reality. It is the status of the descriptions of "sujet epistémique" which remains in doubt, which is to say, it has the status of a hypothetical construct, but differs from the usual interpretation of such constructs in that there are no obvious empirical links to the "sujet psychologique". Indeed, procedurally the attempt is to make the "sujet psychologique" more aware of his intuitions, to make his intuitions explicit, and thereby extend his awareness of "sujet epistémique" (cf. Pylyshyn, 1973b). Or as Chomsky has said "... it may be necessary to guide and draw out the speaker's intuition in perhaps fairly subtle ways before we can determine what is the actual character of his knowledge of his language or of anything else" (Chomsky, 1965, p. 24).

Thus for a descriptively adequate theory of structure we have: (1) necessary and sufficient knowledge for given performance, (2) subjects' awareness of that knowledge, (3) description of that knowledge. Both (1) and (3) might be described as intuition. It is of course desirable to have (3) correspond to (1), yet clearly only part of (1) is open to introspection or awareness. Hence a formal description of (1) is based on the intuitions that subjects' are capable of (2), and on performance. However, it is on the basis of these intuitions that one can claim that those features of the description of cognitive structures, (3), are in fact features of the person and not just of the model, or of the behavior (see McCarthy & Hayes, 1969; Newell & Simon, 1972).

In effect the functionalist-behaviorist methodology always ignores, or rather assumes, answers to questions about what is known, learned, remembered and perceived by virtue of which behavior occurs. Jerry Fodor has suggested in his defence of mentalism, that some patterns of explanation in psychology require the hypothesizing of psychological events and processes which may be arbitrarily remote from behavior and that this contention is "incompatible with any of the behavioristic [read positivistic] strictures upon the relation between observation language and theoretical terms in psychological theories" (Fodor, 1968, p. 86). This suggestion exemplifies his claim that the important issues in the philosophy of psychology converge upon the notion of "functional-equivalence-systems" that must somehow contrive to produce the "same state of affairs" (Fodor, 1968, p. xix). However he goes on to argue that the notion of "same state of affairs" itself requires clarification in the same manner that the notion of "equivalence" does. Thus while functional laws are sometimes understood as causal laws, that is, stating necessary conditions, Nagel points out that such laws which assert functional dependence, while predictive, are not causal laws and say nothing about the temporal or sequential order of events that occur when the law applies (Nagel, 1961, p. 77 ff.). However, as he goes on to point out, functional laws may be interpreted as causal explanations, given a sufficiently isolated system. When the values of the parameters in such a law satisfy the indicated relation between them at any given instant, they will also satisfy this relation at some future time even though the values of the variables change. This point is amply demonstrated by the success of functional explanations within the science enterprise and psychology in particular.

The term 'function' is ambiguous. Insofar as it designates a relation of dependence or interdependence between two or more variables, it is used in its mathematical sense: abstractly defined as any relation between two classes of elements such that for every member of one of the classes, there is a uniquely determined member of the other class. This does not preclude probablistic functions. In this sense, functionalism is consistent with the logical analysis elsewhere in science where the objective is to discover uniformities in some subject matter. Also, in this sense, functionalism stands quite apart from behaviorism, although the latter is clearly functionalistic (Spence, 1956).

However, the meaning of 'function' often shades over into another sense of the word, where it signifies the contribution some variable makes, or is capable of making given the proper circumstances, towards the maintenance of some stated condition in a given system to which the variable is assumed to belong. It is this sense of functionalism, sometimes referred to as teleological explanation, that is employed in biological sciences (Nagel, 1961, p. 401 ff.). However, this use of functional analysis faces serious conceptual problems when applied in the social sciences. For to achieve a functional explanation, quite apart from the condition of isolation, requires the definition of concepts, in terms of the notions applicable to the subject matter of psychological inquiry, which will correspond to the basic formal distinctions in the pattern of these explanations (Nagel, 1961, pp. 526-527). The question, of course, concerns the adequacy of these definitions. And it is precisely here that behaviorism has made itself felt by its focus on verification as the criterion of meaning, conventionalism as an account of its theoretical constructs, and the sharp distinction between inferential and observation language in theory (see Popper, 1959, 1963). And even if it is correctly argued that behaviorism has long ago left this antedated version of positivism (Feigl, 1956; Rozeboom, 1970), it has in doing so become increasingly apparent that the definitions of its central concepts are those of ordinary language often uncritical and inadequate (Rozeboom, 1961b, 1970).

To appreciate this, we must examine the pattern of functional explanation in somewhat greater detail. The formal pattern of functional explanation requires the specification of system *S* and state *G*, maintained in *S*, and the task is to identify a set of state variables whose operation maintain *S* in *G*, and to discover just how these variables are related to each other and to other variables in the system *S* and in its environment (Nagel, 1961, p. 532). In psychology, as in biology, the systems are typically individual organisms. Similarly, in biology, the states that are considered maintained within the system include, among others, the survival of the organism or the condition of 'living', certain characteristic activities of some organ, the internal temperature of the organism, and the chemical state of some internal fluid such as the blood. There appears to be relatively little difficulty in identifying organisms, organs and their characteristic activities. In consequence both *S* and *G* can be clearly identified, and it would seem proper to experimentally investigate whether and by what *S* is maintained in state *G* (Nagel, 1961, Ch. 12).

However, even if this picture is not entirely correct (one need only note the difficulties in specifying such basic notions as 'living' - Minsky, 1967), the problems in defining the states or conditions in psychological inquiry appear to be very much more difficult. For example, consideration of phylogenetic structures and adaptive functions often invoked in explanations of psychological phenomena (Campbell, 1973; Lorenz, 1965), sometimes as implicit premises, are simply not immediately relevant considerations for such complex psychological processes as learning, memory, perception and language. Any proposed functional explanation that invokes these terms constitutes, more often than not, tautology. And where psychological states or processes are not so explained, rather, in terms of concepts employed in the functional descriptions of these states or processes, the latter remain 'phenomenological' unless more explicit characterization is given of the state in question. In the absence of descriptions precise enough to identify unambiguously the state maintained, any claims that such functional relations are definitive or plausible as explanations cannot be subjected to empirical control as they may be compatible with any other state or process. For example consider the following defintions:

1. Memory is the retention of acquired skills or information (Miller, 1962a, p. 349).
2. Learning is a relatively permanent change in behavior potentiality which occurs as a result of reinforced practise (Kimble, 1961, p. 6).

3. The study of concept learning is the study of stimulus selection. The crux of concept learning is the abstraction... of a common feature, characteristic, or property which is present in a number of stimuli which differ on other characteristics (Underwood, 1966, p. 57).

It is evident that in actual research practice these definitions are sometimes adequate, not surprisingly since as they are the result of a body of experimental operations. However, little or nothing is said, here or elsewhere in the above volumes, about the nature of learning, memory or concept formation as changes in the condition of the organism (Rozeboom, 1965). In effect, what usually occurs is that the sequence of the pattern of functional explanation is reversed and the inquiry comes to resemble the more or less straight-forward determination of functional dependencies in its mathematical sense (above). That is, some variable is identified and inquiry is directed to ascertaining what effect changes in the value of the variable have, and whether these changes contribute or affect the maintenance of some state *G* defined in ordinary language and suspected to be fairly stable. Thus in practice it is quite simple to overlook the requirement that system *S* and state *G* with which the analysis deals must be carefully delimited and explicitly defined in the proposed explanation. Similarly, it is easy to overlook the fact that even if the variable has the function attributed to it of preserving *S* in *G*, it may not have this function in some other system to which the variable may also belong, or of maintaining the same system in some other state. A case of the former has been adequately recognized with advances in behavior-genetics (Hirsch, 1967), and the latter has become evident, for example, in considering the differential role of reinforcement in language learning and emotional learning (McNeill, 1970a).

Of course, it was precisely the import of behaviorism which enabled the theorist to explicitly define his terms and concepts. However, when it came to matters remotely mentalistic, behaviorism's adherence to the Vienna Circle's thought model, according to which the meaning of a factual statement had no 'surplus' meaning beyond the operationally defined procedure for verifying it under appropriate conditions, resulted in a "phobia about observables" (Feigl, 1968) and an excessive uniformity of scientific practice (Feyerabend, 1963; Maxwell, 1968) which has not outlived this particular empiricistic ideal of science. It is now commonplace that this ideal of science, and with it the prevailing behavioristic mainstream, has come under attack from various quarters (see Morick, 1972 for a review), and it is accurate to conclude that not a single tenet of this scientific worldview has escaped criticism (Tennessen, 1972). Specifically, the assumed autonomy of facts, theories, presuppositions has been rejected both from the perspective of the history of science (cf. Kuhn, 1970), general science methodology (Polanyi, 1958; 1968; Popper, 1959; 1963) as well as from within psychology (Kessel, 1969; Koch, 1964; Maslow, 1966; Weimer, 1973). It is notable that the impetus for significant alternatives within psychology have become available through the efforts of Piaget and Chomsky both of whom have expressed affiliation not only with empiricism but especially with rationalism.

However, it must not be overlooked that advances in computer technology, which made possible the formulation and application of new ideas, the application of mathematical models and the rapproachment between psychological and neurophysiological theorizing has significantly contributed to the trend away from antimentalistic empiricism. Similarly, it has become increasingly apparent from within the discipline, that in the study of 'higher mental processes; the stricture of a stimulus - response terminology was particularly misleading (Dixon & Horton, 1968). Specifically the problem that has arisen again, and this time in a most forceful manner, concerns that of the organization of 'structure' of psychological phenomena, on both the stimulus and response side, and hence the adequacy of a 'mechanism' that can account for the acquisition and use of this organization. Two ancient doctrines, nominalism and associationism, which have been central to a behavioristic explanation of the mechanism of mind in the acquisition of knowledge, have been rejected as being inadequate (McNeill, 1970a, Ch. 5; Weimer, 1973). Instead, arguments are presented for the conceptual primacy of the abstract entities for both commonsense and scientific knowledge. Essentially the claim is made that persons know more, and can do more, than prior experience and practice can account for. Thus empiricism which maintains that learning and knowledge have their basis in concrete particulars, and, furthermore, maintains that generic concepts are the result of the association of common elements or features of these particulars is juxtaposed to a rationalism which maintains that a particular cannot be known (as an instance of a determined kind) without presupposing knowledge of universal or abstract entities. Presumably, this abstract knowledge is 'structural' or relational and not the result of the gradual association of the similarities of events over their differences (that is, generic concepts), since an association can never be nominalistic (see Neisser's 1967 discussion of the "Hoffding function"), but if it occurs, must occur between abstract entities. To cite from

Ernst Cassirer's discussion of relational concepts:

> The unity of the conceptual content can thus be 'abstracted' out of the particular elements of its extension only in the sense that it is in connection with them that we become conscious of the specific rule, according to which they are related; but not in the sense that we construct this rule out of them through either bare summation or neglect of parts. What lends the theory of abstraction [of relational concepts] support is merely the circumstance that it does not presuppose the contents, out of which the concept is to develop, as disconnected particulars, but that it tacitly thinks them in the form of an ordered manifold from the first. The concept is not deduced thereby, but presupposed; for when we ascribe to a manifold an order and connection of elements, we have already presupposed the concept, if not in its complete form, yet in its fundamental function (Cassirer, 1923, p. 17, parentheses added).

To make a claim for conceptual primacy of the abstract requires an exacting analysis of the product of this knowledge which, as a first step, involves the 'spelling out' of one's intuitive understanding of these events. However, any causal explanation of the product of knowledge must equally take into consideration the person as the instrument of this knowledge. That is the person as the information processing mechanism of this knowledge cannot be legitmately separated from the object or product of knowledge (Hayek, 1952, 1969; Lorenz, 1959, 1965), which is to say that any description of the structure of knowledge is a theory about the person's understanding and, by analogy only, a theory of his world and of his behavior (Cassirer, 1953; Craik, 1943).

A procedure for formulating a structural theory of cognition, which in many respects is similar to the construction of any hypothetico-deductive theory, has been suggested by Shaw, Halwes & Jenkins (1966). It involves the formation of an unambiguous theory of competence with respect to a well-specified class of behavior. That is, a system of elements and operations for deriving those behavioral functions that the organism, in principle, is capable of performing. This essentially involves partitioning the field of inquiry into a minimal set of behavioral instances which are considered clear instances of the phenomenon under study from those which are non-instances and unclear instances. This is followed by writing "rich language descriptions" of all the relevant properties and relations of the behavior. These rich language descriptions, written in terms of ordinary language, may then be translated into "well-articulated statements" which in turn may be symbolized as "well-formed formulae" (Copi, 1954; Suppes, 1957). The latter move requires the introduction of definitions of relationships which connect the various terms used in the well-articulated statements. The goal of these definitions of terms and relations is a set of statement variables which can be operated on to produce well-formed formulae that topographically map the clear instances of behavior. The axiomatization of clear instances of behavior amounts to a theory of competence, expressed as a set of formal rewrite rules, of the organism with respect to the class of behaviors. It is a theory in that the procedure or rules for producing clear instances as well-formed formulae (theorems) is one possible description of the 'deep' relational structures by which the organism may be organizing and producing the behavior. Such a competence theory, to be adequate, must permit the theorist to decide whether novel or unclear 'instances' are in fact instances of the class of behavior under study. This is to say that the theory as an explicit procedure based on the intuitive analysis of clear instances must 'extend' these intuitions to cover novel cases. Such a theory must remain general and yet preclude the generation of "vacuous" functions (behavior) which are mere fictions and also those cases which clearly do not belong to the original class or corpus.

The second step in the formulation of the theory also is the first step in its confirmation. As an "effective procedure" of what the organism can do, the rewrite rule system must contain only rules which are algorithmic in nature, which is to say amenable to expression in terms of a finite set of instructions. It can be shown that for any rewrite system used to express the competence theory, there is a corresponding abstract machine which can compute the outputs which map the theory's generative outputs (Chomsky, 1963; Wilson, 1972). The description of such an automaton is specified formally and is inferred from the nature of the rewrite system used in the theory. Furthermore, it is always possible in principle to construct an actual machine or program that can carry out these computations. However, if such an automaton is in any way to be a model of the organism, that is have "positive analogy", it must include organismic restrictions or empirically justified restrictions on the computational capacities of the automaton. Presumably these restrictions are derived from theoretically well-motivated experiments. Once such restrictions are introduced, the output of the automaton topographically matches or simulates the behavior of the organism or else deviates from it in an explicit manner. Subsequent changes, due hopefully to empirical considerations, can occur in either or both the theory and the automaton (Shaw & Halwes, 1966).

It should be clear that not every operation on elements in the theory need be reducible to observable functional relationships. Rather, such a structural explanation constitutes an effective procedure by which the phenomenon, in principle, could have been produced. That is, such a well defined 'structural' theory has the minimal generative capacity for producing the observed events and hence may be considered an explanation of these events. That is, the test is not one of verification but one of identification (Shaw & Halwes, 1966, p. 10) of explicitly defined states of affairs (Fodor, 1968, Ch. 4).

The solution to the problem of synthesizing a 'mechanism' which has positive analogy to the person is complementary to the determination of functional relations. While the use of automata theory in testing the adequacy of competence models may be some time off, the simulation of both competence and performance variables may be more productive particularly in formulating additional hypotheses that any theory of behavior must account for (Frijda, 1971). It is similarly the case that with respect to a theory of cognition, we do not yet have even "rich language descriptions" of all the relevant properties and relations of the behavior in question. However, the axiomatization of a theory of behavior requires that the elements and operations are not just 'black boxes' or place holders but that these have functional reality and it is perhaps only within linguistic theory that these have been most explicitly defined.

CHAPTER 3

TRANSFORMATIONAL-GENERATIVE GRAMMAR AS A DESCRIPTION OF LANGUAGE COMPETENCE

Perhaps the most familiar linguistic meaning of 'language', at least since the conceptual distinction between diachronic and synchronic study of language, is that synonymously expressed by 'language structure.' On this view language designates a system of relations, or more precisely, a set of interrelated systems, in terms of which speech events are viewed as consisting of discrete units that are organized, within the speech event, according to the constraints of the system (see Lyons, 1968; Stuart, 1964). According to this structural thesis, the speech event designates the articulatory interpretation of the acoustically observed event, where both 'speech event' and 'language' are generic, since different units and their relations are possible. It is precisely this "double articulation" of the expressive aspect of language that renders it both economical as a system of communication and susceptible to a detailed structural analysis (Lyons, 1968, p. 54).

The second sense of language, traditionally more familiar to psychology, designates a system in terms of which individual members of a language community transact with their environment. In this sense language is understood as a system of relations (in the above sense), and expressing a particular content or meaning. The latter is presumably described by a theory of semantic structure. Again the meaning of 'language' is generic which is to say that language as part of the phenomenological world, designates a particular formulated conceptual system with reference to structural and semantic properties. The semantic structure of different languages was viewed by Saussure, for example, in terms of the distinction between substance and form. By form of the language he referred to the abstract structure of relationships which a particular language imposes as it were on the same underlying substance. The substance, he thought to be the entire mass of thought common to mankind independent of the language they speak. The latter he conceived of as a kind of nebulous "... undifferentiated conceptual medium out of which meanings are formed in a particular languages by the conventional association of complex sounds with part of this conceptual medium" (Lyons, 1968, p. 56). Whereas the notion of a conceptual substance independent of language and culture appears to adhere to an outdated psychology, the notion that meanings do involve concepts or ideas is a theme that will be exploited in the pages to follow. It must be noted that the notion of substance was introduced to account for the absence of semantic isomorphism among different languages and determined by the same postulate of 'existence' as the notion of reference (Lyons, 1968, p. 425 ff.).

Language itself is not available for observation and linguistics can describe only what it believes about it. That is, linguistics can describe only the manifestation of its properties at the observational level, or else describe the properties of language at the level of explanation. Propositions in linguistic theory have empirical meaning in case they are supported by descriptive statements, and take on explanatory meaning in the sense that they specify conditions under which one can understand observed events as manifesting language by specifying the structure of the latter. Descriptive statements are in addition to taxonomic labels of observable events, descriptions of these events as manifestations of a non-observable phenomenon is this is conceptually represented in the class of propositions about these events in the linguistic theory.

> Thus the subject matter of linguistic inquiry is not language, but phenomenal events, within an empirical domain of reference, that can be described isomorphically with properties defined by a linguistic conceptual structure or system. Language is the name we give to the phenomenon whose properties are explicated in this way, and our understanding of language is vested in such systems (Stuart, 1964, p. 3).

It is by virtue of this property of linguistic statements that observed events are understood as empirical representations of the theory of language. Therefore, clearly linguistic descriptions are 'theory laden' and directed by our understanding of these events.

It is not always recognized that 'speech' and 'language' designate distinct entities. The speech event or utterance which is ordered relative to some language system, is clearly a biological phenomenon, whereas the language system occurs relative to a socio-cultural context. It is probable that the linkages between language as a biological event, which makes social interaction possible in a process of bio-physical action and reaction, and its expression as a socio-cultural phenomenon, finds its locus in the highest functions of the human brain (see Eccles, 1973). Some time ago it was already cogently argued that underlying language, so understood, there must be abstract mechanisms of some sort that are not analyzable in terms of an associative structure (Lashley, 1951). Indeed Lashley claimed that language presents in its most striking form the "integrative functions of mind." However, the serial activation of motor units appears, as he further suggests, "relatively independent of both motor units and of the thought structure" (Lashley, 1951, p. 118). When the polyglot shifts readily from one language to another expressing the same thought in either, without literal translation, it may be taken as evidence that the temporal integration or structure of his speech is not inherent in the prior organization of the idea. Nevertheless, Lashley maintained the "generality" of the problem of "syntax" of which the problem of language appears prototypic. Thus both thought and action were also considered to be sequential, entailing the problem of serial order, not just of elements but of hierarchies of organization: "... the order of vocal movements in pronouncing the word, the order of words in sentences, the order of sentences in paragraphs, the rational order of paragraphs in discourse." (Lashley, 1951, p. 121).

Linguistic science has made considerable progress in establishing consensual meanings and interpretations with respect to the "internal logic of linguistic structures", particularly at the morphologic and phonemic levels of language. However the fundamental problem concerns the ontological status of the linguistic systems described. Thus are they "... rationalistic constructions that serve a heuristic value without implying an independent and phenomenal existence, or are they proposed descriptions of ordering that occur in some definite empirical space?" (Stuart, 1969, p. 394). The question would appear particularly important insofar as contemporary linguistic inquiry with its focus on syntax, has introduced variables other than those amenable to the "logic of distributional relations" and not only extended the empirical domain of reference, but introduced a new mode of knowing and hence achieved a new kind of knowledge (Bach, 1965; Pylyshyn, 1973b). Thus while the formulation of competence theory (Chomsky, 1964), as exemplified in TGG, has been acknowledged as a shift in epistemological perspective, it is not always clear that its acceptance as a scientific description or explanation has not driven a wedge between heuristic descriptions as rational constructions and linguistic descriptions or explanations as ordering in empirical space. That is, scientific descriptions and explanations cannot be separated from the conditions under which these are established. Meaning and knowing attend upon scientific conditions of knowing. When Chomsky claims this is what I mean by language and the aim of linguistic analysis (Chomsky, 1957, Ch. 1, 2), it is also what he knows about the phenomenon in question. It is well to examine this further.

Considerable confusion has been entailed in the claims made for competence theory (see Derwing, 1973, Ch. 8). But insofar as TGG deals only with the logical or rationalistic combinatorial properties of the primary data, it must be clearly distinguished from a model or theory of language use or performance. TGG was formulated on the analogy between the theory of recursive functions, or more specifically automata theory and natural language (Chomsky, 1956; Chomsky & Miller, 1963). On this analogy it is clearly only another, if sophisticated, descriptive system for reordering the primary data. This was Fodor and Garrett's conclusion, namely that TGG represents only an axiomatization of sentences and their structural descriptions "... such that only the structural descriptions which the grammar assigns have empirical or psychological reality, but not the operations or rules whereby the grammar generates such descriptions" (Fodor and Garrett, 1966, p. 152; see also Bever 1968; Fodor, 1971).

The above was clearly recognized by Chomsky as well. Unfortunately, it was not how it always appeared in print. Thus it was the result of enlarging the empirical base of linguistic investigation, by consideration of both the primary data of speech forms, on which the "structuralists" also based their taxonomies, and certain kinds of native speaker (linguist) intuitive judgements about grammaticality, ambiguity and paraphrase, which led to the notion of linguistic competence. It was this notion of competence, which was said to "underlie" language use (performance), and account for the ability of the speaker to understand an arbitrary sentence in his language and to produce an appropriate sentence on a given occasion (Chomsky, 1966a). It is indeed only as an idealized model of language use or performance that the competence-performance distinction is in any sense analogous to Saussure's distinction between 'langue' and 'parole' (Chomsky, 1964, p. 52, but see Derwing, 1973, p. 260 ff.). As such a TGG, as a competence theory, is essentially equivalent to a set of instructions for performing speech (Chomsky & Miller, 1963).

However, Chomsky has almost from the beginning (cf. Chomsky, 1964), denied that a TGG provides an idealized theory of the speaker or hearer. Rather, a TGG attempts to characterize "... in the most neutral possible terms the knowledge of the language that provides the basis for the actual use of language by a speaker-hearer" (Chomsky, 1965, p. 9). In this sense, a theory of competence is a formalization of the linguistic intuitions of the linguist. However, it is equally clear that a TGG as a system of rules and elements is not open to introspection or accessible to intuition and therefore Chomsky claims that a TGG attempts to specify what the speaker of the language actually knows, but not what he can report about his knowledge (Chomsky, 1965, Ch. I). That is, a TGG based on linguistic intuitions is entirely "tacit." There appears to be then at least two senses of 'knowledge' with respect to the notion that competence characterizes the person's "knowledge of a language". First, 'knowledge' as applied to linguistic intuitions, and second, knowledge of the language as exemplified in a TGG, which is to say as a set of rules that explicitly assigns structural descriptions to sentences. These two senses of 'knowledge' would roughly correspond to knowledge-that, in the case of linguistic intuitions and knowledge-how in the case of the grammar (Harman, 1967; cf. Beth and Piaget, 1966, Chapter 1 above). Yet clearly Chomsky must reject this distinction (see Chomsky, 1969). For TGG as a theory of competence is not a case of 'knowing-that' (not even linguists as native speakers know the rules of the grammar), and neither can the language be characterized as 'knowing-how', since this would force the conclusion that indeed competence is an idealized performance model, or in other words, a model of the speaker-hearer, which Chomsky has rejected.

Nevertheless, Chomsky claims that linguistic competence attempts to characterize what the speaker of the language knows implicitly, and simultaneously, what accounts for the ability of the speaker to understand and produce speech (Chomsky, 1966a). It is in this sense that it constitutes an idealized model of performance. Now as Derwing states:

> What is so peculiar about [this] description is the difficulty of envisaging how competence (construed as a model of 'knowledge' and not of ability) can be regarded as 'underlying' or representing an idealization of performance (which is construed as a description of linguistic ability or performance). There seems to be a disparity between these two notions in kind which we fail to find between the idealized concepts of the natural sciences and their paired counterparts in the real world (Derwing, 1973, p. 255).

Presumably, the notion of idealization in the natural sciences refers to the deliberate deletion of certain variables from the theory or model which is otherwise assumed to be identical with empirical descriptions.

That is, theories or models elsewhere are assumed to be interpretable in terms of some empirical domain under the assumption that the variables deleted are only marginally significant to the phenomena under study. However, the sort of idealization which distinguishes the notion of competence from performance involves far more than the mere abstracting away of the vagaries of performance. In fact, quite apart from the attempts to test competence theory as a theory of performance, the only legitimate base for testing competence theory is the linguistic intuitions that originally figured in the formation of competence theory. Indeed Katz and Fodor have stated:

> The syntactic component ... enumerates an infinite set of sentoids in an order and in a way that must be considered essentially random from the viewpoint of actual speech production and comprehension. The phonological and semantic components cannot change this fact, because they are merely interpretative devices .... Therefore, within the framework of a linguistic description, there is no provision for describing how speakers equiped with a linguistic description of their language can extract from it just the sentences they wish to produce ... (Katz & Fodor, 1964, pp. 166-167).

That is, a theory of competence has omitted something, which Chomsky in other places claimed it obtained, namely the ability to produce and understand utterances that are appropriate to the context in which they were made (Chomsky, 1966b; Chomsky, 1967a). To quote again from Derwing:

> Transformational generative grammars may not be construed as performance models *per se* because under such an interpretation they must have some property akin to recursiveness (which they do) and also the added feature of selectivity (or non-random generation) something which all standard or Chomskyan generative grammars- the models of generative syntax - demonstratively lack (Derwing, 1973, p. 268-69).

Clearly competence models have been interpreted as idealized models of linguistic performance, not only because Chomsky and others have at time written as if they were, but perhaps more crucially because they incorporate the feature of recursiveness which allows, in principle, for the possibility of accounting for the 'creative' aspect of language use. Indeed it is this feature of recursiveness or recursive definition, which may be considered a major contribution of TGG over non-generative or non-procedural structural descriptions. However, language is not only innovative, but perhaps more definitively, it is appropriate to the situation or the context, and yet, as the quotation from Katz & Fodor above makes clear, a TGG fails to meet this criterion. In addition, Derwing points out that a TGG fails to meet the requirement of bi-directionality (see Derwing, 1973, p. 268 ff). That is, as an idealized model of linguistic performance, the grammar must be capable of translating semantic representations into phonetic ones and interpreting phonetic representations in terms of semantic ones. But it is clear that a TGG is presently asymmetric (Chomsky & Miller, 1963).

Therefore a competence theory is not an idealized model of performance. However, as Chomsky asserts "... a reasonable model of language use will incorporate as a basic component, the generative grammar that expresses the speaker-hearer's knowledge of the language, but this generative grammar does not in itself, prescribe the character or functioning of a perceptual model or a model of speech production" (Chomsky, 1965, p. 9; 1967b). Given this position, namely, that competence theory as a characterization of the speaker-hearer's knowledge of his language is so abstract (not just 'idealized') that it requires various heuristics to link it to a performance theory (Halle & Stevens, 1964; Neisser, 1967], it is not surprising that at "... present there exists no satisfactory account of the relationship between a grammar capable of recursively enumerating the sentences and their structural descriptions, and a device (a performance model) capable of simulating the speaker/hearer by recognizing and integrating utterances or sentences" (Fodor, 1971, p. 121).

Indeed, insofar as competence models are based on a restricted class of evidence, namely linguistic intuitions, and forthcoming performance models must satisfy criteria of linguistic behavior (including intuitions), it has been suggested that there exists a " ... crippling inferential gap between the linguist's grammar and the bulk of observable facts of linguistic behavior" (Derwing 1973, pp. 274-275). The inadequacy of viewing the theory of competence as a theory of idealized performance, for example analogous to a subroutine in computer program, is also evident from a consideration of how the competence theory was formulated: that is, from formal considerations alone, rather than from behavioral considerations or the lack of appropriateness to context and the absence of bi-directionality of processing. Thus in the formulation of a grammar an effort is always made to select the most powerful and compact set of rules compatible with the evidence of linguistic intuition - parsimony being the primary concern - wherefore the grammar would be the simplest one compatible with the structural properties of the representation it describes. Clearly, there can be an unlimited number of competence models that would account for the same evidence, that is, which would compute the same recursive function. However, any performance theory must equally be concerned with the psychological complexity of the derivation of different outputs, which is to say that any cognitive (process) theory must reflect the workings of the psychological mechanism. Hence any performance theory must account not only for linguistic intuitions but also for linguistic behavioral data of whatever sort, and hence such a theory would probably not be one that is the most parsimonious account of formalized linguistic intuitions (see Pylyshyn, 1972; 1973b).

What then is the status of a theory of competence? Given that a TGG is related only to a circumscribed data base, namely linguistic intuitions as interpretations based on the output of the generative grammar; that the focus on criteria of notational simplicity is arbitrary; and that competence models are notoriously underdetermined by the data so that any number of such models might suffice, why is it that these are "logically prior" to the formulation of performance models (Chomsky, 1965, 1968; Miller & Chomsky, 1963)? Furthermore, given the experimental failure in corroborating any version of the "derivational theory of complexity", and, hence the claim that any relation between competence and performance will have a degree of abstractness "... proportional to the failure of formal features of derivations to correspond to performance variables" (Fodor, 1971; Fodor & Garrett, 1966, p. 152), how realistic is it that such theories will ever form part of a theory of language use? Indeed given Chomsky's own claim that competence and performance theories are "logically different" in character (Chomsky, 1970, p. 58), how probable is it that the former will ever become an integral part of a theory of performance?

As pointed out above linguistic structures are not actually present in the acoustic space but are imposed upon utterances in some manner determined by the kind of mechanism the brain may turn out to be, that is by speakers and hearers. Linguistic descriptions are contingent in some manner on what is known about language and to what goal theories of language are directed. Linguistics, whether pre- or post Chomskyan, whether conceived as a purely social system or else as localized in the individual mind, was concerned first of all with the structure of language, that is, with language as a 'product'. Any structure attributed to language as product, if it is to be more than an arbitrary classification scheme, must receive its empirical realization in the process of language production and comprehension. However, the latter is no more than to say that structure is complementary to function and that the empirical reality of structure must be sought in the inquiry of how that structure functions (see Levy, 1968). The emphasis here is on the fact that both structure and function are complementary (Hormann, 1971). It seems misleading to argue, as Derwing does for example (Derwing, 1973, pp. 310-311; Schlesinger, 1967), on the basis of the "inherent logical gap" between competence and performance theories, that, if only we replace the "abstract notion of the rule" with a dispositional concept "of putting rules to use" meaning "behaving according to rules", where all that is required to learn such rules are "general capacities which most humans possess," namely, the " ... power to discriminate, generalize and ... extract regularity from the environment," we can resolve the difficulty by doing away with competence theory. The basic objection to this is that it is precisely the latter "capacities" which require explanation. To demonstrate that a speaker " ... does behave according to the rule in a situation which is novel to his linguistic experience" (Derwing, 1973, p. 311), and that this in turn is evidence that the language user has learned a "surface structure constraint," simply does not address the question of how these linguistic abilities reflect _what_ psychological processes.

The distinction between competence and performance theories reflects the conviction that the first step in the psychological explanation of language use must be to understand just what aspects of the utterance are perceived, learned, and retained for future use. In the case of language, it is clear that these aspects are not simple classes of physical properties of the waveform or language 'product', rather, they are 'abstract' properties whose relation to the stimulus may be quite obscure or "arbitrarily remote". It was Chomsky's criticism of linguistic theories that remained at the level of "observational adequacy," that these theories ignored a class of evidence about language, namely linguistic intuitions, which precluded these theories from ever becoming theories of the language user. Instead, the goal of linguistic theory should be to provide a formal account of linguistic intuitions and to achieve a theory of language that has "descriptive adequacy." It is the use of 'intuition' as a source of evidence that, perhaps, presents the most radical departure from contemporary methodology in both linguistics and psychology (but see Köhler, 1929). However, properly pursued, the use of intuition is a perfectly proper method in science (see Luchins and Luchins, 1965; Heyting, 1966). As Pylyshyn points out, the use of intuition relies on the "... elimination of putative structures by the construction of counterexamples" (Pylyshyn, 1973, p. 30). In the formulation of TGG, a proposal for a particular structural property suggested by some initial 'intuition' is then tested for generality by constructing examples based on the proposal and which are "acceptable," and the structure with the greatest generality is considered as well-motivated (see Koutsoudas, 1966). Presumably the "hallmark" of the good linguist, is to produce appropriate examples to illustrate the postulated structures and counterexamples to deny such structures. Clearly the use of intuition does not exclude the use of language as product, albeit often the product of the linguist.

The formalization of a person's intuitions in terms of a TGG or a 'procedure' adheres to at least two other considerations. First is the fundamentally rationalist conviction which claims that the record of behavior, the 'product', can best be understood once the distinctions assumed in some sense contained in people's mental representations, are formalized. The claim is that to understand language use, or any other kind of intelligent behavior at all, is to describe the distinctions which must necessarily obtain by virtue of which any performance, including intuitions, is made possible and which any psychological mechanism must eventually be able to take into consideration. The concern with mental representations derives from the important conceptual point, namely, that which is functional in cognition is not what is necessarily available to introspection or intuition or to the direct observation of behavior. Equating cognition and awareness is phenomenally quite compelling particularly in the case where cognitions are expressed in language. However, it is axiomatic that in any system which examines itself there must ultimately be some part of the mechanism which is inaccessible to examination. Therefore in the study of language, cognition, or of any intelligent behavior it is strategic to distinguish two types of inquiry: the first is the 'functional' question related to the acquisition and use of knowledge as exemplified in behavior; the second is the 'structural' question related to the characterization of those mental structures or distinctions that are necesarily part of the person (mechanism), and to which he does not have conscious access, given his abilities to perceive, understand, reason and speak. These two questions are clearly complementary. However, the latter may be considered the theoretical problem pertinent to the question of "what the organism knows" and hence a theory of competence.

A second consideration is that the structure of the distinctions that are part of the mental representation cannot be merely characterized as a code or mediator for an external event, that is, as a list of elements more or less static in nature. Rather, these representations are themselves best characterized as rules or procedures which may be recursively applied. To take as an example the notion of "plan" as put forward by Miller, Galanter, & Pribram (1960), it is clear that such plans function as hypothetical (construct) devices in the explanation of behavior. However, it is unreasonable to believe that such hierarchies of plans are present prior to the occurence of behavior. Instead, they are formulated and function in the course of behavior by some presently unknown mechanism, a description of which must clearly include a generative capcity. That is, while plans have been shown to be "isomorphic to some S-R model at asymptote" since they are each isomorphic to a finite automata (Suppes, 1969), this may be the case for a fully articulated plan but it does not follow that such a simple automata is sufficient to describe the competence model that accounts for the formation of such plans and eventually behavior (Pylyshyn, 1973b; Wilson, 1972). Indeed, in the case of the syntax of language, Chomsky has shown that nothing less than a context-sensitive grammar is sufficiently powerful to account for the corpus of sentences (Chomsky, 1956; see also Wilson, 1972).

To understand this it must be clear how the problem was first formulated. The problem, in brief, addressed the question of the formal relation that holds between a concept as a distinguishable set of stimuli, and an unbounded number of qualifying instances of that concept, exemplified, for example, in the concept "grammatical sentence in English". What characterizes such concepts is that membership in them cannot be specified by any finite list of elementary features or combination of features. Therefore any finite specification of which instances belong to the concept must analyze the instances into some finite set of constituent parts or features which, together with some set of operations applied to the features and to the result of the previous application of these operations, provides a procedural description of every instance that belongs to the concept. It must be clear that such a procedure as a TGG does not describe how people go about producing and understanding sentences, but such a procedure does describe one possible 'abstract' relation that obtains between the concept "grammatical sentence in English" and a string of words or some transcription of an utterance.

Such a representation or theory of competence is in no way arbitrary. The elements and operations, that is, the structure of the representation, as well as the representation as a whole, is related in a systematic manner to the possible elements and operations in the stimulus. That is, the structure of the theory of competence is related to the manner in which the stimulus is analyzed, and in the case of syntax this includes the intuitions of the speaker. It should be evident then that competence theories are not about behavior or its mechanism, but rather about possible mental representations. But what is the status of such representations given the previously stated objections? This reduces, I believe correctly, to a single complex issue. What is the most reasonable representation of language as product, including linguistic intuitions, in mind of the person (Pylyshyn, 1973b). Furthermore, given the goal of formulating a theory of language use that meets the criteria of empirical inquiry, how useful is such a representation as a first step in theory construction? It is maintained here that as a first step towards understanding behavior, we must understand what for the subject are "the relevant aspects and structures of behavior" and that the formalization of this structure specifies what any theory of behavior must eventually account for. This may mean testing competence theories as if they were performance theories, but not likely. It means working at a theory of language with whatever means are scientifically available, and more so, revising competence theories continuously to meet criteria of conceptual and experimental adequacy (cf. Shaw, Hawles, & Jenkins, 1966, Chapter 1, above).

What is in question here is the old orthodoxy of empiricism (Rosenberg, 1970). Thus Quine, for example, wishes to predict observable speech behavior given observable stimulus conditions (Quine, 1960, Ch. 2), and for this something like the hypothetico-deductive method of traditional empiricism is quite adequate. The old orthodoxy offers us two kinds of inference; deduction and induction, whereas the "new empiricism" offers us a third: "inference to the best explanation" (Harman, 1965). This is to say, that the test of an account of empirical phenomena (or laws) is the extent to which it explains what we already know about those phenomena. In Sellars phrase, theories " ... explain empirical laws by explaining why observable things obey, to the extent that they do, these empirical laws" (Sellars, 1961, p. 71). If a theory does this job, we have good reason for accepting it and, *inter alia*, for believing that the unobservables postulated by the theory are true of the world. Given its adequacy, prediction may not be very much to the point. Chomsky has clearly recognized this third kind of inference. If one provides the best explanation for the unobservable encompassed by traditional empiricism, then this *is* the best explanation. The scientific realist, as opposed to the instrumentalist, will then accept the terms in his explanation as referring to something in the world. Of course, the goodness of fit of the explanation turns on more than considerations of the linguists' corpus, but then this is precisely the point about 'competence'. In chapter 4 I will attempt to specify some of these considerations for a theory of cognitive learning.

CHAPTER 4

LINGUISTIC THEORY AND SOME REQUIREMENTS FOR A THEORY OF THE PSYCHOLOGY OF MEANING

The second sense of language introduced above is that referred to as 'semantics'. The study of semantics as a branch of linguistic science investigates the meaning or the signification of language. Semantics has had a rather varied status within linguistics. Thus Bloomfield maintains: "In language forms cannot be separated from their meanings.... It is only the differences in meaning, which decide that most of the inevitable variations of sound are irrelevant.... [However] there is scarcely any limit to the varieties of meaning ... by the combination of a few dozen recognizable elements of sound. It follows from this that the study of language must start from form and not from meaning" (Bloomfield, 1943, p. 102). On the other hand semantics has been equated with the entire field of linguistic study (Firth, 1957), including emotive, imitative, figurative, and stylistic uses of language (Ullman, 1962; Wheelwright, 1968). From a philosophical perspective, semantics has had a more narrow scope with the focus on its 'denotative,' 'cognitive', or 'conceptual' meaning, taking account of its significatory property and the interrelation of words and sentences on the basis of this property. So understood, the meaning of linguistic signs involves not only the signs themselves but, *inter alia*, what they refer to. Perhaps the best known such analysis of language is the tri-partite analysis of Ogden & Richards (1923).

With respect to this tri-partite analysis of meaning, Ullman has taken the position that the linguist must focus only on the relation between the symbol and the reference (sense), but clearly, such an analysis is cognizant of the range of reference to extralinguistic phenomena (or referent, cf. Ullman, 1962; Olson, 1970). However, the metaphysical reliance on thought or concepts in the analysis of meaning has often been rejected in favour of a behavioristic (Bloomfield, 1933) and contextual (Firth, 1957) analysis which have equated wherever possible meaning and referent. Unfortunately, this has led to a rather exaggerated distinction between words which refer to tangible phenomena, as perceptually present, and those which do not have a referent of this type. Such a distinction poses real problems since in a sense all language signs are equally 'abstract' yet in another, their meanings are not equally dependent on correlation with extralinguistic events. Perhaps a more satisfactory relationship between form and referent was conceived of by Morris. He viewed the language vehicle (form) itself as an object and its denotation of other objects resides solely in the rules of use which correlate the two (Morris, 1938, 1946). The 'meaning' of a sign is neither equated with the referent as Bloomfield would have it (see Esper, 1968), nor with thoughts or images as Saussure's proposal for a 'structural semantics' (Saussure, 1966), but as part of a network of social conventions which convert the 'forms' of spoken or written language from 'noises' or 'marks' into linguistic 'signs' (Searle, 1970; Spence, 1968). Bloomfield's difficulty about the meaning of abstract signs which have no referent in some sense disappears with Morris' claim that every sign has a 'designatum' but not necessarily a 'denotatum' (Morris, 1946).

Meanings for Morris are intersubjective, that is, the rules of use for both sign-sign (syntax) and sign-referent (semantics) relations are social in nature and language at the semantic level can neither be equated with the 'forms' of signs nor with the objects which these denote. Clearly, the correlation of a sign system with the extralinguistic world through the concept of use or function involves the person who performs this feat or what Morris terms the 'pragmatic' aspect of language. However that may be, the latter was considered to lie outside the scope of linguistic study proper, and was to be treated within the framework of 'metalinguistics', a field covering the interrelationships of the different cultural systems, including language, within a particular society (Trager, 1949). However, how the study of a point-by-point relation between language and any other cultural system was to advance the understanding of 'meaning' and hence the metalinguistics of that culture remained quite obscure. A more pragmatic approach which made reference to the 'context of the situation' (see Malinowski in Ogden and Richards, 1923), and 'collocations' within different semantic domains (Firth, 1957), did not look for point-by-point correspondences but rather, accepted the meaningful unit of language as the 'utterance' and attempted to relate it to the total context including the linguistic context. Evidently, this approach requires a degree of abstraction of 'relevant social features', 'typical contexts' or 'typical collocations' and such an effort may eventually come to look like traditional lexicography. Thus while the 'total' meaning of an utterance cannot be apprehended outside its context or situation, the 'general' meaning may often be quite independent of a particular context, and more recently within psychology, resort to the perceived context is made only in case of meaning disambiguation (Olsen, 1970). This position has the appearance at least, of being more crucially psychological or mentalistic, with its focus not on words but on sentences. In any case, it is evident that in a formal interpretative account of semantics (Katz & Fodor, 1963), the semantic markers and distinguishers on which these authors base their account of meaning, are determined by non-linguistic factors (Bolinger, 1965; Macnamara, 1971).

Reference is in some degree a factor which is both determined by the language system as well as one which determines meaning (of a language). Even in the case of words which have concrete referents, perceptually present, meanings are based on the structures existing within the language system. From a linguistic perspective, one can presumably distinguish syntactic from semantic aspects of meaning as proposed by Morris, or say distinguish between 'internal' and 'external' meaning (Dixon, 1965). However, from a psychological perspective it is reasonable to maintain that the referential function of language is merely one of its functions.

Saussure's synchronic structural approach to semantics maintained that meaning derives from a term's place relative to other terms in the language. This position is at least implicitly mentalistic since it does not seek to study correspondence of sign to referent, rather, to study the rleationship between signs, or concepts expressed by these signs. There is the further assumption that differences in meaning are discrete and dependent upon the relative contrasts within a language system as exemplified by componential analysis of particular cultural systems such as colour and kinship terms, combinatorial semantics, and various 'field theories' of semantics. A mentalistic or conceptualist position is less susceptible to linguistic relativism (Whorf, in Carroll, 1956) than say a contextual approach, as it can maintain the universality of certain linguistic signs as properties of the human mind. Similarly, the fact that neither form is predictable from context nor context from linguistic form, has led contextualism or behaviorism to a probabilistic method of analysis and the focus on the formal distribution of forms within utterances (collocation) to their socio-cultural context (situation). Unfortunately, such phenomena as synonymy, antonymy, translation and paraphrase are beyond the scope of such an analysis, as, indeed, the underlying postulate that language is a significatory system appears irretrievably mentalistic.

Mentalism in modern linguistic semantic theory is disguised by its adherence to formalism. The major difference between the two is that the latter need not entail any assertion of corresponding mental states or entities such as 'concepts'. Formalism in semantics at least implicitly honours the distinction between meaning and reference or, with a slightly different implication, between intension and extension.

Within linguistics, semantic analysis has traditionally been concerned with word (morpheme, lexeme) meanings and indeed, structural semantics has often assumed that semantics is the study of vocabulary. The relationship between semantics and syntax remained implicit insofar as meaning was discussed with reference to words as grammatical units. Recent developments have made a more radical distinction between grammar and semantics and have analyzed the latter in terms of units more explicitly set up for that purpose: 'features', 'markers', 'categories', 'cases', 'propositions' or just 'concepts'. This move has several advantages over either a componential or combinatorial analysis of semantics. In particular, the latter analysis which has been concerned to derive sentence meaning from word meaning has had to spell out the difference between the grammatical and logical or psychological meaning structure of the sentence. 'Spelling out' these differences points the way to a mentalistic or conceptual analysis of meaning. Similarly, insofar as a behavioristic or contextual theory of meaning must be concerned with sentences and their corresponding states-of-affairs, such an analysis of meaning is necessarily propositional, cognitive, and hence mentalistic.

There have been various attempts to incorporate the linguistically formulated notion of competence within more general psychological models of cognition. Insofar as these attempts have viewed the TGG as a performance model these have been misguided. However, the extrapolation from a linguistically restricted notion of competence in which syntax constitutes the primary component, to a more general conception of competence incorporating propositions about mental states appears potentially much more fruitful. Thus it has been suggested that one way in which syntactic competence models can be become more valuable as potential performance models is to expand the empirical base upon which they were first formulated. This would imply a change in the model from one in which the syntactic component is central, to one in which the semantic component is the generative source. The distinction between 'deep' and 'surface' structure in a TGG assumes that the deep structure provides the input to a semantic interpretation, and that therefore sentences with different meanings have different deep structures. Semantics, so conceived constitutes a purely interpretative system and the assignment of lexical items is contingent on deep structure syntactic constraints (see Katz & Fodor, 1963). However, it is equally possible to conceive of a competence model in which semantics as the generative source determines the initial choice of semantic representation and where the syntax has a secondary status. Such a move does not make competence theory any more of a theory of performance but it does, in meeting additional intuitions and empirical constraints, provide a more tenable or potentially useful set of representations on which to build a performance theory of language.

More recently two viewpoints have emerged which give priority to the semantic representation of the deep structure, one from within the domain of TGG (see a review Perfetti, 1972), and the other form within the domain of computer simulation of semantic information processing (see a review Frijda, 1972). It is generally agreed by both these approaches that sentences express certain relationships that are 'deep' in the sense that they are not manifest uniformly in the surface structure of sentences.

Fillmore (1968a, 1970) has argued that the base component of the grammar does not consist of a series of phrase structure rewrite rules as in TGG, but, rather that it consists of unordered case relations which have both syntactic and semantic significance - relations which are only indirectly evident in the surface structure. While case relations are treated as syntactic primitives, they have semantic correpondence and in fact the deep structure of the sentence is thought to be propositional, having a verb and at least one case category. A 'case grammar' can recover the basic relations expressed by a subject-predicate phrase structure, and since the order of the case constituents in the deep structure is arbitrary, it has a greater degree of 'abstractness' and the additional power of representing shared characteristics of the subject and object. A series of ordered transformations carry the propositional deep structure to its surface structure. The propositional component is essentially a modified predicate calculus, in that what is conventionally a verb becomes a predicate and what conventionally are nouns become arguments. The latter are generalized case categories that are represented with the verb as inherent arguments (Fillmore, 1968b), and hence are relations and not, strictly speaking, categories at all. That is, the arguments are 'stored' with the meaning of the verb. For example, the arguments [Place, Instrument] are 'inherent' to the verb 'hit', while [Agent] is not inherent but a compatible argument for the verb 'hit'. The subject and predicate are strictly surface structure functions in the case grammar and the rules for the surface structure realization of arguments must be associated with each predicate (Fillmore, 1970). Despite Fillmore's focus on semantics, he maintains the centrality of syntactic analysis of the theory of language, but argues that such an analysis reveals important semantic distinctions.

McCawley (1968a) similarly rejects the necessity of a syntactic deep structure and instead proposes that the deep structure of a grammar consists of " ... a 'formation rule component' which specifies the membership of a class of well-formed semantic representations, and a 'transformational component' which consists of rules correlating semantic representation" (McCawley, 1968b, p. 165). The restrictions on how words may be combined are the semantic restrictions of "possible messages", and are derived not from syntactic selection restrictions but from the "limits of experience and imagination" (Perfetti, 1972, p. 245). That is, the restrictions on sentence formation are imposed by the presuppositions concerning the denotation of lexical items, which is to say, by the semantic structure, not by the rules of syntax. Like Fillmore, McCawley claims that syntactic categories are realized only in the surface structure. Deep structure categories are similar to those in symbolic logic, with "subordination", consisting of a "proposition" (verb), with at least one index which also appears with the noun phrase constituents of the deep structure and which are used to identify the indices of the proposition. The semantic constituent structure also goes through an intermediate stage; lexical items in the surface structure are the result of transformation on the deep semantic constituents (McCawley, 1970b). For example, Postal (1970) derives the verb 'remind' from the deep semantic structure of the form 'strike as similar', or as Perfetti cites McCawley's example, the simple verb 'kill' is derived from 'cause to die' (Perfetti, 1972, p. 247). McCawley describes his grammar as transformational but not generative, in contrast to Chomsky. He furthermore draws a distinction between a sentence and a proposition: a proposition is a 'contentive' (Verb or act) plus a sequence of indices which effectively constrain the sentence by "index at least one noun" correspondence (MacCawley, 1970b, p. 178). Hence, the information in the deep structure is clearly abstract and relational.

Relational information within a TGG is primarily achieved by the syntax with both the phonological and semantic properties of individual lexical items being interpretative and typically represented by a matrix of distinctive phonetic and a matrix of semantic features respectively. The attempt by Katz & Fodor (1963) to spell out the semantic component in terms of a dictionary and a set of projection rules to yield a meaning interpretation of the syntactic structure has, despite the various criticisms (Bolinger, 1965; Macnamara, 1971b; Weinreich, 1966), had considerable impact in psychology. For example, the semantic features have become psychological concepts in that they represent information available to the language user. However, semantic features as psychological concepts should then not be defined, *a priori*, by linguistic criteria or by linguistic theory as is presently the case. For one thing there would appear to be no principled limit on the number of semantic markers (see MacNamara, 1971b). For another, the distinction between linguistic and non-linguistic knowledge (Katz & Fodor, 1963) appears to be more motivated by a desire to fill out an interpretative semantics than to provide an account of 'meaningfulness'.

Proposals that incorporate semantic features as concepts in models of long-term memory (Bower, 1970; Kintsch, 1970; Miller, 1969; Quillian, 1968, 1969) all assume that those features represent information a language user has stored in an 'internalized' dictionary. However, the criticism by Fillmore and McCawley with respect to the deep syntactic structure sheds doubt on the purely interpretative role of semantics. Thus a case can be made that a structural analysis of the syntactic component equally applies to the semantic component, words and morphemes, as well (Leech, 1970; Weinreich, 1966). Leech, for example, suggests that words such as 'blind' and 'laudable' are as amenable to structural analysis as to feature analysis. Thus constituents realized as 'that cannot see' and 'which ought to be praised' can be said to underlie 'blind' and 'laudable' respectively. More generally within a lexical item, semantic elements combine in the same way as in larger sentence constituents (Weinreich, 1966). The meaning of 'blind' not only contains the meanings of 'cannot' and 'see', it contains them in exactly the same relationship as 'cannot see'. Conversely, the lexical distinctions explained by feature analysis are applicable to constituents as well. Hence, under the assumption that there exists a level of semantic constituent structure, a sort of 'generative semantics' questions the entire notion of semantic features as abstract components which restrict the combination of individual words. The point here is that what is stored in the lexicon is not a matrix of features, but rather entries governing the use of the word based on its assumed denotation. Thus while it may be correct to argue that each lexical item has a basic sense characterization which may well require semantic properties of some sort, this is of no particular theoretical status. What is important instead are the inherent arguments, the interpretation restrictions on inherent arguments, implicit arguments, case suppression, surface structure relations of arguments and various other facts (Fillmore, 1968b, 1971). Thus, in the case of anomaly, it is the semantic presuppositions represented with the lexical entry, the interpretation restriction on inherent arguments, which are not clearly met. For example, the normal interpretation of 'break' restricts it to objects which are rigid. However, rather than argue for a feature [+rigid], there is a restriction on the inherent argument of 'break', namely [object] and that these denote things that are characteristically rigid. One of the considerations that emerges from this critique of feature analysis is a renewed focus on the role of reference. Olson (1970) for example suggests that meaning be conceived of as the information that differentiates among the perceived or inferred set of alternatives. Any characterization of this information is clearly different from that of a semantic feature analysis and closer to an analysis in terms of propositional and hence structural form.

The analysis of semantic information or 'meaning' has benefited perhaps most from the simulation of human memory. Thus Frijda (1970), who defines memory as "human information storage and retrieval", claims that any such system must meet at least four criteria: The system must be (1) content addressable, (2) have the capacity to retain factual information, (3) have inferential potential, and (4) display flexibility in retrieval. To meet these minimal requirements the information store consists of a relational network where the basic functional 'information element' consists of a "concept with a predicate or an entity with a property" (Frijda, 1970, p. 4). Such a unit, as Frijda goes on to suggest, can be considered as a cognitive 'scheme' (Bartlett, 1932; Piaget, 1952), a 'gestalt', (Asch, 1969; Wertheimer, 1959), or a 'relational fact' (Selz as cited by Mandler and Mandler, 1964). The relational network consists of a collection of overlapping schemas with as many links as the number of relations the systems is capable of distinguishing. (The classical link of 'association' may be described as a relation of 'simultaneity' or 'followed by'.) The relata of each concept can be considered as the meaning of that concept or idea. In turn each element (relata) of this meaning is itself defined by its environment in the network; the network clearly embodies the hierarchical structure of information or knowledge (Frijda, 1972; Wilson, 1970). Quillian (1968) defined the immediate surroundings of the concept or 'node' as its 'immediate definition" and the entire field accessible from a given node as its "full concept." It follows that the meaning of a concept can be defined as "that selection from a concept's full meaning (or its "sense characterization"), that is focused on by the task at hand" (Frijda, 1970, p. 5). The meaning of a concept is, in a sense, as variable as those tasks.

Similarly, each cognitive schema may itself function as an element in another schema yielding a network of unrestricted complexity. Because schemas may point back to those in some way above them, the network itself is not hierarchical, but a "general graph rather than a tree" (Quillian, 1968, p. 29). The structure of such a network is implicit in the pattern of linkages between the nodes or concepts. That is, the relations have meanings defined within the network, either in terms of their possible arguments (as in the "case" grammar) or as rules of inferences which are read as other schemas (implicit in formation) or else as operations that the system can execute upon its own data (for example, "synonymy"). It must be made clear that while, for example, Quillian's program uses words in referring to the content of its memory store, the elements stored are to be thought of as concepts or ideas (Quillian, 1967, 1968, see also Wilson, 1970). This conception of the memory network has, as Frijda points out, important consequences for the internal representation of information. The network is in effect a large number of access-ways which ultimately lead to procedures for the composition of word/sentence meanings, images and activities. That is, the network is in principle 'constructive' and not 'reproductive', as Neisser (1967) makes this distinction. The latter notion of (re)constructiveness, has been used by Quillian (1969) to deal with the problem of syntax. Thus, the meanings of words in the input string are retrieved and possible common associates noted, thereupon possible relations between the words are constructed from the information in memory which is then syntactially tested for correspondence with their function in the input string. Such a matching procedure, once the possible meaning of the input has been determined, is also employed by Schank (1972) and Schank & Tesler (1970).

Schank provides a fine example of the insights which may be derived from the simulation of natural language comprehension. He began his work with the initial premise that the basis of natural language is conceptual. That is, he postulates an interlingual base onto which linguistic structures are mapped during comprehension and from which linguistic structures are formed during speech. Such a conceptual base has as its operands concepts and relations which function in thought and of which natural language is an expression. What is represented in the conceptual base is the meaning of an utterance. Presumably the conceptual base does its job when two linguistic structures (in any language), if they are translations or paraphrases, have the same conceptual structure. The initial form of his "conceptual dependency structure" reflected primarily the surface structure properties of English. However, subsequent work has led to the use of more abstract or generic concepts as the basis of this conceptual structure (Schank, 1973). His conceptual structure is based on conceptual case rather than on syntactic case, and has as its basic paradigm the actor-action-object sequence. A meaning representation must contain each and every concept and relation that is explicitly and implicitly referred to in the sentence and hence language comprehension in this model does away with any distinction between linguistic and non-linguistic knowledge as conceived of in a purely interpretative account of semantics.

Computer simulation of semantic memory processing has in principle, provided a more or less coherent model of language processing. The model essentially consists of a large network of 'associations' in which the nodes refer to ideas and the links to relations between those ideas. The ideas may be simple or may themselves be composed of small networks that manifest complex and unorderly interconnections. Such a network may be considered as a system for the reconstruction of inputs rather than as containing any sort of reproducible trace of those inputs. Presumably external stimulation makes contact with the network via some kind of discrimination process which may include some kind of transformation mechanism to standard form (Frijda, 1972; Neisser, 1967), or else occur by the continual interaction with the memory store itself, as is the case with both Schank's and Quillian's proposals.

Both the shift within linguistics from an interpretative semantics as proposed by Chomsky and Katz & Fodor, to a "generative semantics" as exemplified in the work of McCawley and the "case grammar" of Fillmore, and the advances in the simulation of semantic memory, appear to move toward a more genuine cognitive semantics or mentalistic explanation of linguistic meaning.

However, by stressing the distinction between meaning and language, it is not intended to fall into the "fallacy of substraction" (Quine, 1960, p. 206), but rather to point out that an utterance is the "embodiment of thought" in language (Saussure, 1966). A similar viewpoint was also expressed by Wilhelm Wundt, who treated meaning and language as a psychophysical entity which may nevertheless be theoretically distinguished (see Esper, 1968, Ch. I). In accepting this position, without necessarily accepting its metaphysics, it is implied that any account of linguistic meaning must be based on the language user's knowledge of the world. It is precisely this thesis which has been fruitfully maintained, in spite of the research focus on syntax, by those interested in the child's acquisition of language (Bloom, 1970; Macnamara, 1972). It is this knowledge of the world, which involves categories of meaning that in some sense correspond to events in the world, which is expressed in language. Hence 'meaning' refers to all that can be expressed or designated by the linguistic code, and 'cognitive meaning' in a narrow sense refers to that which can be so expressed and which, in addition, has some correspondence with objects and events in the world. As has been suggested and as will be argued later, these meaning categories are of a propositional nature and hence will, more often than not, be linguistically expressed as sentences (Frege, 1952).

In spite of the commonsense relationship assumed to exist between words and sentences and objects and events in the world, linguistics has, as pointed out above, abandoned ary attempt to address the problem of reference in favour of a formalistic sense characterization of meaning. Similarly, behavioristic accounts of the problem of meaning in terms of reference have focused primarily on connotative meaning (see Terwilliger, 1968) and have postulated mediational or representational responses at the word level (Osgood, 1963, 1968). Recent recognition that any such account must include the speaker's knowledge of the intended referent does little to advance this claim insofar as there has been no attempt to formulate an explicit description of that knowledge in relation to the referent. As words do not have meaning in and of themselves, nor are they labels for events, any such a description must, as Ogden & Richards (1923) already recognized, include the person as the mediator in the relation of word and referent. However, while Ogden & Richards' claim that an utterance is a symbolization of a reference and that a reference may more or less approximate the structure of the referent (ideas may correspond to events in the world), as Olsen points out, any reference may be symbolized in more than one way, and how or why this can occur is not specified by Ogden and Richards other than to indicate that in discourse the objective is to specify the same referent (Olsen, 1970). As was pointed out above, the Ogden & Richards' account was elaborated by Morris and also by Wittgenstein (1958), who suggested that the meaning can only be formulated through use within a specific context or language "game". Brown (1958) makes the same point to the effect that naming is relative and reflects both the context of the utterance and its use within a culture. He finds that the common name for an object differentiates an object at the level of its usual utility. However, as Olsen points out, this formulation is inadequate, for any theory of reference must specify the relation of the perceived referent in a particular context with respect to the restrictions imposed on the corresponding utterance. In other words, a theory of semantics is not independent of a theory of knowledge (of the intended referent).

Olsen's own influential theory of reference suggests that the "meaning of an utterance is, therefore, the information provided by the utterance to a listener .... and is dependent on the context of alternatives." More specifically "utterances specify an intended referent relative to the set of perceived alternatives from which it must be differentiated" (Olsen, 1970, p. 264). The advantage of this position appears to be that an utterance encodes the partitioning of perceived alternatives, that is, its meaning is encoded both in terms of perceptual and semantic features. It is precisely because of this that Olsen is able to claim that there "... is more information in an utterance than in the perception of an event out of context" (p. 265). However, since the freedom of language from its perceived context is perhaps one of its prime characteristics, Olsen is forced to assert that the making of "semantic decisions is a highly abstract process that goes well beyond the sense data gathered from the referent" (p. 268-269). In drawing one of the implications of his position Olsen points to the asymmetry between speaker-hearer: for the speaker there is no information in the utterance since presumably everything is perceptually available to him (speaking is redundant), while, for the hearer the utterance affects or influences his thought and hence serves to instruct him. Olsen concludes that this consideration permits one to " ... effectively eliminate the higher levels of cognition and the deeper levels of language" (Olsen, 1970, p. 272). While the latter appears consistent with recent semantic formulations of the deep structure, the former cannot be so easily dismissed if for no other reason than that speakers are also hearers and that "semantic decisions are highly abstract" (Olsen, 1970, op cit).

It has been the theme of this paper so far, that an adequate grip on the concept of cognition must come to terms with the problem of the nature of the representation of cognition or the structure of cognition. It may be useful to distinguish two types of structure: abstract structure and perceived structure. The former develops as the person interacts with his world and refers to the "residue of experience" which permits the continuity meaning and is not open to introspection or reflection except as it becomes part of the perceived structure. The second type of structure is that of perceived structure and refers to information which is phenomenologically available to the person. Perceived structure, which is not conceived to be independent of the abstract structure, is in effect, situationally specific (cf. Feather, 1971, pp. 356-357).

Concomitant with this distinction in structure is a formal distinction between state and process variable put forward by Rozeboom

(1961b, 1965). Thus variables whose constellation of values for a system at any given moment are an exhaustive description of the system's condition at that moment differ in the degree to which they are influenced by variation in the internal or external input variables. To quote Rozeboom:

> ... process variables are those whose stability is essentially no greater than that of the input variables (where these may also be included among the system's process variables), while state variables are those which remain essentially constant .... under uniform variation in the process variables (Rozeboom, 1965, p. 340).

The distinction is of course a relative one, one of degree; state variables are what is distinctive about the organism independent of its particular immediate environment, whereas process variables are those conditions which come and go with the transient detail of the organism's stimulus' surrounds, including internal stimulation. In particular, Rozeboom suggests that dispositional attributes characterized in terms of what process properties the individual would have, were he to be exposed to a certain input condition, are in general state properties which persist even when these input conditions are not in fact present.

What is important to this distinction which parallels the two types of structure mentioned above (that is, state variables belong to the abstract structure and process variables to the perceived structure) is that "... each state variable causally involved in the doings of a reactive system is to a greater or lessor extent mirrored in the mutable interdependencies among the system's process variables" (Rozeboom, 1965, p. 341). Thus input variable $\underline{X}$ and state variable $\underline{S}$ jointly determine the value of output variable $\underline{Y}$ and as such the dependency of $\underline{Y}$ and $\underline{X}$, and $\underline{S}$ may be characterized by $\hat{Y} = f(S, X)$. If $\underline{S}$ remains essentially constant at time $\underline{p}$, the form simplifies to $\hat{Y} = f_s(X)$, in which $\underline{Y}$ is essentially a function of $\underline{X}$ but where this dependency depends upon the temporally stable state property $\underline{S}$. Given that S remains constant for a sufficient period of time, long enough to permit testing of the system's response to the various values of the input $\underline{X}$, and hence allow determination of the relationship $\hat{Y} = f_s(X)$, or else that the system's $\underline{S}$ values change over extended intervals of time, or different systems have different $\underline{S}$ values, these are all governed by the law $Y = f(S, X)$. In these cases the local dependency of $\underline{Y}$ upon $\underline{X}$, as characterized by the parameters in f_s, is an empirical *structural* variable which acts as an observable counterpart to state variable $\underline{S}$ no matter how inaccessible to direct observation $\underline{S}$ may be (See Rozeboom, 1961, pp. 357-358). That is, with respect to each other, $\underline{X}$ is a process variable and $\underline{S}$ a state variable, if $\underline{S}$ has sufficient local constancy relative to variability in $\underline{X}$, that the relation of $\underline{X}$ to other process variables can be ascertained under essentially fixed values of $\underline{S}$. Conversely, wherever interdependencies among process variables are discovered to differ among comparable systems or else show long term changes within the same system, we may postulate the existence of a theoretical state variable, of which the process-relations are observable manifestations; while the empirical regularities which are found to determine the parameters in local process-relations are the source of the laws hypothesized to govern these theoretical state variables (Rozeboom, 1960b, p. 362 ff.). Clearly, state variables are not just mediation variables, and process variables need not be behavioral.

This methodological interlude has certain implications with respect to the problem of characterizing cognitive representations or memory structures. Thus Olsen has argued, as was previously indicated, that a theory of semantics must be a cognitive theory insofar as linguistic utterances express the speaker's perception (knowledge) of the intended referent relative to a set of alternatives. However this may be, Olsen goes on to conclude that "... words neither symbolize, stand for, nor represent referents, objects, events ... rather words partition the event on the basis of distinguishing [perceptual] features" (Olsen, 1970, p. 265). He then turns to the environmental context to demonstrate his point. However, such a description/explanation remains entirely within what was termed the 'perceived structure', phenomenologically available to the speaker and essentially variable with the environmental context. What is ignored, given Olsen's own conception of the function of language, is that any causal explanation of speech must include not only a characterization of the speaker's knowledge of his language but also a characterization of what is known upon which language operates to express the intended referent. That is, linguistic decisions, whether semantic or syntactic, are made on the basis of what is known (state variable) for it is precisely on the basis of this knowledge that the speaker is able to educe or differentiate the intended referent from its alternatives. Thus when Olsen states: "Once the speaker has decided on the intended referent, and the perceived or inferred alternatives from which he must differentiate it ..." (Olsen, 1970, p. 269), he assumes all the problems that require explanation. Olsen's position remains essentially peripheralistic with the exception that he regards the sentence as the vehicle for expressing the content of perceptions.

Nevertheless, the latter indicates an important advance. Presumably the internal articulation of the content expressed in the sentence has the complexity equivalent to a proposition. Propositions are here defined as well-structured *concept* complexes whose linguistic counterparts, sentences, consist of lexical items in distinctive positions within a syntactic frame. It is precisely the propositional structure, or what has up till now been referred to as a relational structure, of mental events which distinguishes among their content. If in addition we maintain Olsen's conception that the propositional content of mental events is about something, that is, refers to or represents some referent as distinguished from its alternatives, we have our two requisities for a theory of cognition. The claim that the content of mental events is about something else, some perceived or inferred event, is what is generally understood by the term 'intentionality'. It is both intentionality and the propositional structure of mental events that are the essential characteristics of cognition (see Rozeboom, 1972, p. 37ff.).

The claim that the formal complexity of mental events or acts are at least as complex as that of a proposition was already articulated by Wundt (Blumenthal, 1970; Esper, 1968) in the notion of substance or idea; however, it has recently been pointed out that only an event as complex in structure as expressed by a sentence can properly lay claim to the term stimulus (Rozeboom, 1960; 1960a). The claim that persons respond not to discrete elements of the situation but to the "situation-as-a-whole" is another manner of recognizing that it is events or facts, of which objects and properties are ingredients, that elicit behavior. According to Rozeboom:

> "... by trying to make simple terms do the work of expressions which need the formal structure of a sentence, behaviorists have adopted a conceptual framework, which, entirely apart

> from the meaning of the concepts employed, lacks sufficient formal complexity to cope successfully with more integrate psychological phenomena such as perception, semantic processes, beliefs, etc." (Rozeboom, 1960, p. 166).

It is precisely on the basis of this criticism, namely that the conceptual structure employed in a behavioristic-functional analysis is insufficiently complex to deal with genuine psychological phenomena, that empirical considerations converge upon the close relation between language use and cognitive processes. The claim that language competence is purely linguistic, "that language is *sui generis*" and that the human faculties it calls upon are not employed in other performances (Simon, 1969, p. 48), is here rejected in favour of a view that the human capacities for producing and understanding utterances depend not only upon certain characteristics of the human nervous system which are common to all language users, but are also essential to other aspects of human performance apart from speech.

It is not necessary to repudiate off-hand certain strong assumptions about nativistic competence capacities, particularly as these do not contradict the thesis that language, perhaps more than other cognitive processes, is a human construction. The former simply claims that there are limits on the 'inner environment', on the kind of information processing mechanism which the organism is, and as might be expected these limits are inferred in part from an understanding of the structure of language. The claim that language is a human construction asserts that these inner environmental limits are rather broad limits on organization and not specific limits on syntax or semantics. Such limits are not specific to language but probably apply to every mode of representing experience. Such a view is quite congenial to the mentallistic thesis that "only the thinkable is expressible" and consistent with the relational view of concepts which are the operands of thinking (Cassirer, 1953, 1955) and probably of perception and imagery (de Groot, 1966). However, it is only with respect to language and thought that the implications will be pursued in chapters 5 and 6.

CHAPTER 5

A CAUSAL-STRUCTURAL DESCRIPTION OF CONCEPTUAL ABSTRACTION

Presumably all psychological theory makes certain claims about the organism as a mechanism, however implicit as such claims may often appear. In particular, it has been argued above that such claims made by a functionalist-behavioristic psychology are insufficient and need to be supplemented by a structuralist description. Apart from certain boundary stipulations such as those that relate to 'living', historically the pivotal psychological problem appears to surround the biological notion of successful adaptation from a phylogenetic viewpoint, and the psychological notion of the ability to benefit from experience from an ontogenetic viewpoint. Hence the centrality of such topics as perception, learning, and memory. The problem of adaptation involves the inheritance of certain biological mechanisms which are capable of modification through experience in a particular environmental context. Indeed modification is essential if the organism is to cope with the varied nature of its environment. Therefore the process of modification, or any theory of learning and memory *ipso facto* postulates the existence of certain biological inherited mechanisms capable of 'performing' what this learning process entails.

In fact, the claim is a stronger one. Any theory of learning makes certain assumptions about how these mechanisms, capable of modification through experience, work. For example, if contiguity or frequency are important variables in the learning process, one must assume the existence of a mechanism capable of taking into account temporal parameters in learning in the first instance, and discriminating and summating frequencies in the second instance. Analogously, if 'similarity' is an important property for counting events as belonging to a particular class, there must be a mechanism capable of defining this notion of similarity, for example, in terms of size, colour, shape, and function. Of course, the claim that there must be certain phylogenetic mechanisms is only a first step, since presumably a psychological theory of learning or memory must be more specific in its claims about this apparatus which permits modification through experience. Such claims are about the necessary preconditions by virtue of which the organism can acquire knowledge from its environment.

As has been maintained here, from a structural perspective, a theory of learning or the acquisition of knowledge will necessarily concern itself with the organism as an "information processing mechanism." That is, the object of knowledge and the 'instrument' of knowing cannot be legitimately separated; a characterization of what is known, a theory of competence, will also concern itself with the apparatus of knowing. For example, in linguistics we find not only a description of the speaker's knowledge of his language but the accompanying speculations about the mechanism required for its acquisition. A structural characterization of language as exemplified in a TGG not only requires careful delimitation of what is learned but also some strong claims of what is required to learn it. With respect to the former, the formulation of competence theory accounts for both the requirements of 'novelty' or the creative aspect of language as this comes to light in individual utterances, as well, their unboundedness or their freedom from stimulus control. With respect to the acquisition of what such a competence theory describes, this has resulted in some very strong assumptions about the nature of the mechanism of mind, (Chomsky, 1968; McNeill, 1970b).

Consider, for example, the centrality of the phenomenon of 'productivity' in Chomsky's account of language.

> The most striking aspect of linguistic competence is what we may call the "creativity of language", that is, the speaker's ability to produce new sentences, sentences that are immediately understood by other speakers although they bear no physical resemblance to sentences which are "familiar" (Chomsky, 1966a, p. 11).

This is to say that speakers can display knowledge (of their language), for which their prior learning history has given them no specific preparation or, rather more precisely, for which the formal mechanism of stimulus, response, and association theory cannot, in principle, provide an adequate account. That this is indeed the case is evidenced by the fact that learning theories have simply denied the phenomenon of 'novelty', or what Chomsky refers to as "creativity," in the serial order of psychological phenomena including productive thinking and language use. Dollard & Miller (1950) maintain, for example, that apparently novel response patterns are but new combinations of old responses or sets of responses conditioned to cues or sets of cues which, prior to learning, elicited these responses but very infrequently. "The connection between cue and response is the new product of learning. Often a number of different response units are connected to cues so that they all occur together, either simultaneously or successively. Thus a new pattern of responses is produced; the responses are old, but the combination is new" (Dollard & Miller, 1950, p. 37). Similarly, more sophisticated mediation learning theories maintain that serial order is a matter of the association of elements of behavior and their mediational equivalents (Jenkins, 1963; Jenkins & Palermo, 1964). And even with respect to acknowledged creative and discursive phemonena, Berlyne for example, in his discussion of "productive thinking" maintains that "productive thinking takes place when past learning is subject to modification and reorganization, ... [and] ... is typically a product of stimulus-response generalization, and it invariably permits of wide extension to future problem situations through further stimulus-response generalization" (Berlyne, 1965, pp. 315-317). That is, association theories of learning, whether behavioristic or gestalt (Köhler, 1941), are "copying" theories (Neisser, 1967), insofar as learning cannot occur unless some concrete particular elements of the stimulus remain invariant. That is, the exact stimulus situation must somehow be instantiated in apparent novelty or else there would be nothing to learn from, or, to which to transfer prior training. It is on the basis of this requirement that Fodor (1965) ean reject association theories as adequate theories of meaning.

It might be objected, of course, that this much is also admitted by Osgood (1966, 1968). But then Osgood goes on to point out that the crucial difference between single-stage and two-stage theories of learning is precisely the "... functional separation of decoding and encoding phases (S-r and s-R)" (Osgood, 1968, p. 502). It is this functional separation which gives the mediation model the capacity to incorporate symbolic processes. To quote from Osgood:

> ... the notion of r_m as a simultaneous bundle of events in a limited number of component reaction systems possesses combinatorial properties which should render distinctive representation compatible with biological economy. The total momentary pattern of components of r_m can be thought of as a kind of code, which represents for the organism those differences among R_T's which make a difference with respect to responding appropriately to *S*'s or things signified. To maintain this capacity, there is neither the requirement that

> each r_m be unique from all others in all respects ... nor the requirement that all ways in which R_T's differ from each other be represented in their r_m's (only those ways which make a difference in meaning are required) (Osgood, 1968, p. 502).

However, as was pointed out above, and cogently argued by Pylyshyn (1972, 1973b), the formal relation that holds between a concept and instances of that concept is such that, if there are a near infinite number of instances belonging to the concept, any representation of that concept cannot be a simple selection of some (arbitrary) code. This is the case, even if, as Osgood has argued, such a code may be considered as a set of parts or "bundle of features", because such a representational code would have to be given "... in terms of a prior analysis of instances into a finite set of elementary parts or aspects" (Pylyshyn, 1972, p. 549). Similarly, it adds very little to suggest, as Osgood does above, that "distinctive representations be compatible with biological economy", for this simply begs the question. Any concept, and there is good reason to believe that this would include most concepts, for which there is no apparent upper boundary on the possible number of variations of qualifying instances, in order to be describable in a finite manner requires a procedural description.

Behavioristic theories of learning reflect both the nominalist bias, namely, that all our knowledge of the world is of concrete particulars acquired by way of the senses; and the associationistic bias, namely, that all organization, whether of simple habits or directed thought, is a matter of the various laws of association defined among these concrete particulars. Essentially, such a position requires that little attention be given to the mechanisms of mind as indeed has been the case. This does not deny that there are no problems of abstraction. However, these present no new problems and are explicable by demonstrating that behavior is dependent on only certain properties in the stimulus pattern and by discarding those which are not part of the concept. Hence all knowledge is a construction of associations of concrete particulars. (It is not the purpose of this paper to attribute this view to any philosophical tradition as any such attempt would probably be incorrect. However others have done so; see Lewin (1931) on the distinction between Aristotlian and Galileian modes of thought; Bach (1965) on the Baconian versus Keplerian view of science; and Weimer (1973) on the Platonic versus Aristotlean view of concepts.)

Chomsky has repeatedly criticized association theories as insufficiently powerful mechanisms to account for the "creativity" displayed in language use (Chomsky, 1959, 1965). Not only is there the problem of the requirement of an infinite number of associations and the related difficulty as to their storage and retrieval, but the more fundamental conceptual problem that such associations could not have been learned at all as there is nothing invariant in the social context to learn these from when novelty is exhibited. Generalization presupposes invariant elements from which new associations can become established. But there is simply no such phenomenon as generalization for abstract entities. Weimer (1973) has made this point most emphatically when he states that the term 'generalization' refers to a process or mechanism which assumes that similarity (of elements) "... alone imprints itself on the mind. The similarity in diversity is made manifest to the mind *as such*. Elements cannot be similar ... unless they are recognized as similar" (Weimer, 1973, p. 25 footnote). However, just what it is for perception to order events or properties of events into a series of similars, or that (dis)similarity does not appear in perception along with other perceptual qualities of particular events or properties of events appears to have been ignored. That is, the phenomenon of generalization and by implication that of concept formation presupposes what it was intended to explain. Of course, this criticism is one which I have already referred to with respect to behavioristic-functional explanations and the rejection of structural descriptions or what Kohler within another context has referred to as the commission of "experience error" (see Köhler, 1929).

The manner in which Chomsky has come to terms with the 'creative' or productive phenomenon of language is to employ rules in the grammar that range over inherently abstract entities which never appear in actual speech. The "explanatory primacy of the abstract" (see Weimer, 1973, p. 25) is essentially the reason for the two primary distinctions within contemporary linguistic theory: competence-performance and deep-surface structure. The former acknowledges the asymmetry between 'knowledge' and experience, or as I have used the terms, 'abstract' and 'perceived' structure. Knowledge is essentially a structural property of mind (as formulated in a theory of competence) which is causally related to, but as an abstract system quite removed from the production of speech. Similarly, the deep-surface structure distinction, which is a distinction within the competence description of language, is meant to explicate the abstract nature of meaning from its mode of representation in particular utterances. It should be noted that both the semantic component of the deep structure and the transformational rules of the surface structure are abstract but not necessarily to the same degree. In any case there would appear to be some ambiguity associated with the status of the representation of the surface structure; presumably, performance exhibits, but is not synonymous with the surface structure.

This ambiguity may be appreciated if we examine both the competence-performance and deep-surface structure distinctions in terms of the abstract and perceived structure distinctions put forward above. As will be recalled, abstract structure (state) variables are not phenomenologically available and are essentially stable properties of the person, while perceived structure (process) variables are, or potentially are, available phenomenologically but tend to be situationally specific. It is competence which describes those processes of the deep structure which are abstract, stable, not phenomenologically available and hence belong to the abstract structure. A formal description of this abstract structure, however, is dependent upon linguistic performance, including intuitions, which form part of the perceived structure. Now, in case of language, several alternative theoretical perspectives are equally valid: thus one can examine its function in communication, its dependency on context, or, in the case of contemporary linguistics, its 'productivity'. Given the validity of the latter perspective what has become the starting point of this investigation is not speech, rather the formal concept "a grammatical sentence in English" which is exemplified both in speech (perceived structure) and as the output of the abstract structure. Insofar as it constitutes a fact of speech, it belongs to the perceived structure but insofar as it is the formal characterization of the output of the abstract structure, it represents an "empirical structural variable" (Rozeboom, 1961b, op cit), which is the observable counterpart to the abstract structure, which of course, is itself not available for observation. Therefore the apparent ambiguity of the surface structure representation derives from its status as the causal output of the abstract structure and its "idealization", in the sense of its formalization, of actual speech.

The import of his digression is again to point out that any theory of language use necessarily requires a behavioral model more powerful than that of classical associationism which "defines the rules over the terminal vocabulary of a theory" (Bever, Fodor & Garrett, 1968, p. 583). Wilson, in a lucid discussion of the various types of grammars and their relation to behavior models, states that the central objection to stimulus-response association theory "... appears to be that S-R theories are essentially linear generators and so cannot account for generation of behavioral sequences which can be generated by a context-free or context-sensitive grammar" (Wilson, 1970, p. 14). Wilson goes on to point out that even if the "terminal meta-hypothesis" (Bever, Fodor & Garrett, 1968), has been accurately criticized for having dealt with an "impoverished version of S-R theory" (see Kintsch, 1970), and that in principle such models can be shown to correspond to context-free grammars which " ... permits the non-terminal symbols or 'responses' of higher order units to correspond to finite automata" [and] "the possibility that the adaptive behavior ... can also occur at levels above that of terminal motor responses" (Wilson 1972, p. 18, 20), such models are still insufficient to handle context-sensitive grammars. Thus while a number of theorists have recognized something akin to a behavioral model of a context-free grammar, or what Wilson elsewhere has discussed as a "hierarchical list structure" (Wilson, 1972, pp. 366-367), it is clear that nothing less than a context-sensitive grammar (as opposed to a context-free or phase-structure grammar) is required to describe natural language (see Chomsky, 1956, 1963). Thus in the processing of natural language as proposed by Shank (1972), which involves the parsing of natural language and the search for plausible relations and implications, a behavioral model is required the structure of which is capable of handling concepts or their meanings as related to sentences and not individual words (in sequence). While it is presently not at all clear what such an abstract structure would like like, it is clear that it would not simply consist of associations but would have asymmetries corresponding to relations (Frijda, 1972), and that such relational or propositional schemes be "capable of simultaneous activation" (Wilson, 1970, 1972).

The former does not preclude that cognitive or linguistic processes are not basically serial in their operation (on the surface structure). People can only process a few symbols at one time and these are 'held' in limited memory structures or what was previously referred to as perceived structures whose content is changing, or rather, dependent upon the vagaries of a changing environment. Hence the complexities of the content in the perceived structure is largely a matter of the complexity of this changing environment. Nevertheless, when one turns from the serial processing restrictions of the perceived structure and focuses instead, because of the problems of natural language processing and others, on the nature of the organization of the abstract structure, the formal requirements for organization appear to be minimally a context-sensitive or perhaps at more abstract levels context-free structures (see Wilson 1970, 1972).

The intended import of this somewhat technical discussion is that the phenomenon of 'productivity' or novelty is not restricted to language and may be applied to all behavior and mentation as previously suggested. It is specifically with respect to the nature and acquisition of concepts, as these are presumably the 'elements' of which propositions, beliefs and their corresponding linguistic encodings are composed, that the phenomenon of novelty is a particularly apt one. Thus the question presents itself, what is the nature of what is learned and remembered (retrievable from memory) that allows the organism to recognize non-identical recurrences of the (same) event? As will be argued below, this formulation of the problem cannot be adequately handled by the traditional theory of concept formation which appeals to such terms as discrimination, attention, and generalization which themselves implicitly assume a characterization of what is known. That is, the processes designated by these terms are based on behavioral evidence which makes insufficient claims about the mechanisms which perform this feat and hence cannot incorporate certain cognitive achievements of the kind here labelled 'cognitive abstraction'. However, any effort to revise the theory of concept formation (or the structure of knowledge), requires a conceptual revision with respect to what is learned and remembered and the 'kind of mechanism' that can perform the job.

The problem of concept formation, or, so that it may be distinguished from the experimental literature so labelled, the problem of conceptual abstraction, is one at the most elementary levels of knowledge acquisition. It presupposes the capacity to learn to perceive, 'store', and 'utilize' information. Just as Neisser (1967) has argued that any perceived event must remain peripheral until it makes contact with some centrally stored information, many others have pointed out that no association can be effected without the recognition that some particular stimulus is like some previously experienced event (Asch, 1969; Köhler, 1929; Oldfield & Zangwell, 1943; Posner, 1969; Wallach, 1958). The problem of conceptual abstraction is a problem to the extent that something must be postulated by virtue of which the organism can deal with present events. Or, more specifically, what is it that is learned and that characterizes that state or condition of the organism (memory or abstract structure) which permits it to recognize (perceived structure) recurrences of events? Clearly, the difficulty is with the term 'recurrences'. Where all events either perceived as completely novel events, or else as identical events, there would simply be no problem pertaining to learning, memory and consequently conceptual abstraction. Clearly, organisms function somewhere between these two extremes. Whatever the nature of the mechanism ultimately implicated, the requirement is that the organism recognize the 'relatedness' of events to previously experienced (known) events. It is this understanding of relatedness which avoids the hypothetical extremes of a single equivalence class and infinitely distinguishable particular events (see Carroll, 1964). The question of conceptual abstraction becomes: How to characterize what is retained in memory and retrievable from it that allows the organism to recognize non-identical recurrences of events?

This question has historically been addressed by a theory of the concept. Perceived events are understood to be instances or examples of concepts. In fact, so pervasive is the phenomenon of the equivalence class that we ordinarily speak of "concepts as encountered in the world." The problem of the novelty, or the multiplicity of experiences is dealt with in terms of mechanisms (formally concepts), which allow novel events to be dealt with in terms of past experiences, and hence concepts may be thought of as mechanisms effecting a "psychic economy" (Bruner, Goodnow & Austin, 1956; Elkind, 1969). The problem consequently concerns the claims which a theory of concept formation must make about concepts which will permit an explicit description and hence understanding of the notion of 'relatedness'. The 'meta-problem' of the nature of the concept, or of conceptual abstraction, concerns the most general ability required of a mechansim capable of modification, or of the ability to utilize past experience (knowledge) for adequately dealing with novel, but in some sense, related events.

To explicate the notion of 'relatedness' two issues must be confronted: first, what is learned when a concept is acquired, and what is it about the nature of the concept that permits the organism to recognize non-identical instances of the concept or to demonstrate transfer to novel instances of the concept? Second, what is the relation between what is learned and stored (as concepts) and the events experienced and presumably necessary in the acquisition of the concept? That is, what is the relationship between experience and knowledge, for it is a description this relationship which constitutes the basis for determining the kind of mechanism the organism must be.

In summary, the theoretical problem of conceptual abstraction may be formulated as follows: recall, recognition and more generally understanding an event as an instance of a previously acquired concept is some function of what is in memory. The nature, organization or structure of memory is here designated by the phrase 'abstract conceptual code' or abstract structure. Furthermore, presumably the nature of this abstract conceptual code is some function of what is learned or what constitutes the necessary, if not sufficient condition for learning:

experience. Given the inadequacy of a functionalist-behavioristic analysis of behavior which maintains that current novel events evoke a response solely on the basis of an exact replica in memory, then the question becomes what alternative formulations are available with respect to nature of what is learned and what is in memory? It is here assumed that what is learned is in the nature of concepts, and hence that the theory of concepts must have some implication for what is understood by 'learning', for the relation between experience and knowledge, and for the requirement of a mechanism that can perform this function.

The literature within psychology directly related to the problem of conceptual abstraction is that of concept formation and utilization. It is not my intention here to be critical of this research from a methodological perspective, rather to question its adequacy from the standpoint of the theory of the concept implicit in most of this work (see also Flavell, 1970; Newell & Simon, 1967).

The array of intuitions included under the rubric of concept formation is extraordinary. However, most of the paradigmatic research in the area of concept formation, whether concepts are peripherally defined in terms of stimulus or response equivalence classes (Kendler, 1966, 1968), or mediational 'meaning' responses defined in terms of common meaning responses or features (Berlyne, 1965; Bourne, 1966; Bruner, Goodnow & Austin, 1956; Osgood, 1968), simply do not even address the question of the nature of the concept but assume its existence. Whatever the differences, and these are extensive, all these positions have in common a theory of the concept which claims that organisms form concepts to the extent that they are able to discriminate and select common features, elements, attributes, or 'meanings' from among the events experienced. It should be noted that even Osgood in his discussion of semantic generalization, where he defines meaning independent of verbal or other behavioral responses defines similarity of meaning or 'relatedness' in terms of the number of meaning responses or features which different concepts (or instances) have in common (Osgood, 1968). The implicit understanding of the nature of the concept evident in all these positions is that of a list or 'summary' of common attributes 'derived' from experienced events which are 'related' (by these common attributes) and which are, by virtue of these common attributes instances of the concept. Furthermore, as Simon has argued, concept formation studies tell us little more than that persons may be instructed to use strategies to take account of the defining attributes and that the "bottleneck" of these experiments lies in the "small amount of rapid-access storage (so-called short-term memory) available and the time required to move items from the limited short-term storage to the large-scale long-term store" (Simon, 1969, pp. 33-34). In summary, these studies have little to say about concepts and less about organismic restrictions.

Bourne's recent reformulation of the theory of the concept (Bourne, 1968, 1970), in terms of rules defined over attributes, appears to provide a degree of structure and abstractness previously left implicit. However on closer examination it may only be an embellishment over the common attribute position insofar as the rules are themselves concepts (granted of a peculiar nature) which together with other concepts (attributes) provides considerable insight into something which Rozeboom (1972) has termed "inductive reasoning" rather than concept formation. However, this formulation of concepts provides but little more insight into the structural nature of the concept since Bourne cannot distinguish, for example, between "red conjoined with triangle" and "red triangle" (see Asch, 1969). The point here is not that the research into concept formation is not important or that it has not given considerable insight into the requisites for the utilization of concepts, rather the objection is that a strictly behavioristic-functional approach has not concerned itself with the question of the nature of concepts but assumed it as part of its paradigmatic investigation.

The theory of concept formation from the 'common element' viewpoint is essentially as follows. The intension or defining characteristic of the concept is a set of features (elements or attributes) which are perceptually simple and which all instances of the concept have in common. Sometimes this may include certain non-perceptual operations or 'rules' which are descriptions of sensible feature groupings. The relation between events and concepts, as well as the relation among different concepts, depends on the features these events or concepts have in common with other events or concepts - hence an instance or exemplar of a concept or of a 'higher-order concept' qualifies only in case the event or concept has all the features that define the concept or higher-order concept respectively. The relation between an instance or exemplar and the concept, that is, the relation between particular and universal, is one where the concept represents a subset of all the various features that characterize a particular instance or exemplar. Hence, novel events qualify as instances of a concept only in case they contain the necessary defining features, and these events therefore represent the extensional definition of the concept (see for example Gregg, 1967). It is therefore axiomatic that the universal be contained in every particular.

What are the implications of this theory of the concept, or what, from a more theoretical perspective, may be considered as its assumptions?[1] First, consider the implications for the relation between experience and knowledge. That is, the implication of what the organism learns when it learns concepts, and how that knowledge (concepts, not knowledge of concepts) is related to what was experienced during the acquisition of these concepts. The theory claims that this relation between experience and knowledge is one of subset to set. That is, information is essentially lost in the formation of concepts, or in the acquisition of knowledge, relative to what is experienced. This is to say that all those features of events that are not definitive of the intension of the concept are ignored. These features are 'accidental' with respect to the concept. Hence what is learned is knowledge *of* past experience, *of* features, *of* feature groupings, or structures where simple rules of conjunction, disjunction and still others are defined over perceptually simple features (see Bourne, 1970). This relationship between knowledge and experience as one of subset to set, has certain implications for a description of any mechanism which is expected to demonstrate such performance.

Thus, presumably with respect to some goal, a particular set of features belonging to some event is assumed to leave some 'trace' in memory. It is this trace of features which intensionally defines the concept. It is this trace which is repeatedly 'activated' by novel but related events, that is, events related to the concept because they have features like those activated by the memory trace. In successive perceptions a connection is formed or 'account is taken of' those events which have features similar to those which intensionally define the concept, and these events or instances become the extensional definition of the concept. It is, of course, only those features which are 'similar' or common to successive events which define the concept. Hence what is stored in memory and what is part of the concept (trace) is a gradual predominance of similarities over differences. Discrimination and attention become the primary psychological processes, and instruction (of strategy) and temporal parameters (in acquisition) become the principle variables of investigation (see Trabasso & Bower, 1968). While there is little doubt that discrimination and attention are necessary processes in learning concepts, whether by ostension or definition, these are not sufficient to characterize just what it is that is learned. For while these processes are central in the selection of instances from non-instances, they do not address the question of the nature of what is stored by virtue of which these processes can operate, and since the intension of the concept is identified with its extension, the problem of 'novelty' is rejected.

This rejection of novelty was previously mentioned and becomes particularly evident when an account of the recognition of novel instances is considered. The intension of a concept, as was suggested above, is in the nature of a list of features or matrix of commonalities, with perhaps certain 'idiosyncratic notes', and novel instances are recognized as belonging to the concept only to the extent that they contain these critical (combination of) features. That is, the theory of the concept is nominalistic insofar as the same stimulus or response situation must be instantiated in apparently novel instances to permit recognition (see Berlyne, 1965 op. cit). Thus novel instances are not really 'novel' but must contain features which also belong to the concept and recognition is a matter of matching these common features in novel instances with those stored as defining the concept. Another manner of stating this is to claim that every instance must contain the universal concept, and hence, that discrimination and attention are processes required to distinguish those features which define the concept from those which are accidental at least with respect to the concept.

Finally, since concepts are defined in terms of the features which events have in common, the more general or more inclusive the concept becomes, the less information that it contains insofar as there are fewer features to be found in the intersection of its instances. It should be noted that it is precisely the selective encoding of only certain features that gives the concept its generality; where this is not the case each concept would be represented as a code at the level of specificity of actually experienced events. However, the consequences of this view of concepts, where the degree of abstraction is directly related to a loss of information, and where the entire information structure comes to resemble, for example a taxonomic hierarchy in biology, has some serious drawbacks. Apart from the strongly counter-intuitive claim that the most general concepts contain the least information, such an information structure must now confront the problem of characterizing a concept as a list of other concepts (instead of features that are perceptually simple), each of which must in turn be defined from a common element viewpoint. However, more serious is the difficulty in remembering or recognizing instances of very general concepts as this would require a search through the entire hierarchy.

Finally, defining concepts at every level of the hierarchy in terms of the intersection of all the features contained in its immediately 'lower' sets, simply precludes the question of the nature of the concept - which is where this investigation began.

A critique of the traditional 'common element' view of concepts rests on several theoretical considerations. First, very different events can be instances of the same concept and yet have no apparent elements in common. This criticism is devastating, however it is sometimes countered with the claim that there is some kind of 'functional' equivalence among dissimilar instances. Unfortunately, just what this functional equivalence (biological or social-psychological means-end relations) would mean formally is not stated. The second criticism, one that has only recently been appreciated, is that any adequate characterization of a concept involves much more than a simple listing of features or elements and their logical connectives. A minimum characterization must explicitly state the relations among these elements and procedurally derive instances of the concept. Finally, the notion that a concept is defined by common features is essentially a 'subtractive' thesis. It conceives of concept formation as the learning and retention of only common information, with resulting generality and 'psychic economy', but with a corresponding degree of loss of information.

These three criticisms are prescinded by a more general criticism that the features or elements, which are part of the concept formation research paradigm, are themselves concepts, often primitive and perceptual in nature, about which there is no stated problem. This criticism is not decisive in any particular concept achievement study. However, it becomes an essential consideration in the characterization of the theory of the concept.

From a theoretical perspective, these four criticisms of the traditional view of concepts really converge upon the inadequacy of the notion of structure. That is, this view has made inadequate claims for the complexity of the organization of cognitions which are about states-of-affairs themselves highly structured. Köhler pointed to this fact when he claimed that perceptual groups are recognized not because their members have specific properties, but because the group as such has certain characteristics which are necessarily abstract. Thus the phenomenon of similarity is not due to the existence common elements; in fact often there are no common elements (in the stimulus). Instead the notion of similarity or relatedness is necessarily an abstract one. Any adequate theory of the concept must be capable of describing this abstractness (Köhler, 1940). Hayek points out, along similar lines, that the order of events is something different from the properties of individual events, and that the same order of events can be formed from elements of a very different individual nature. Orders involve elements plus relations between them and the same order or structure may be formed by any elements capable of entering into the same relations with each other (Hayek, 1952, 1969). Furthermore, an order, gestalt or pattern (Uhr, 1966) is a structure whose meaning lies not in its disparate parts but rather in the fact of its structure. Gibson (1966) has made this same point by distinguishing stimulus energy from stimulus information, where the latter is invariant over fluctuations in the former. In summary, the problem of characterizing the structure of concepts requires more than a simple listing of elements (and logical connectives), particularly since different events which have no elements in common may yet be instances of the same concept. More recently, Hayek has made this claim most explicit. Consistent with his previous writings that everything we know about the 'external' world consists in the classifications effected by the action patterns of the functioning nervous system (see Hayek, 1952), he now claims that human knowledge is a system of rules of determination that indicate equivalences and differences of various combinations of input patterns. The conceptual primacy of abstract structure is that:

> We ought to regard what we call mind as a system of abstract rules of action (each "rule" defining a class of actions) which determines each action by a combination of several such rules; while every appearance of a new rule (or abstraction) constitutes a change in that system, something which its own operations cannot produce but which is brought about by extraneous factors.
>
> This implies that the richness of the sensory world in which we live, and which defies exhaustive analysis by our mind, is not the starting point from which the mind derives abstractions, but the product of a great range of abstraction which the mind must possess in order to be capable to experiencing that richness of the particular (Hayek, 1969, p. 318).

The fact that instances or exemplars of concepts need not have any features or elements in common precludes that concepts can simply be characterized as a list of such elements. This view was already implicit in the Gestaltists' claim that the whole (structure) is different from the sum of its parts, and has recently been experimentally demonstrated by manipulating these 'wholes' or structural properties directly (Asch, 1962, 1969). However, care must be exercised in the interpretation of this type of research with respect to its criticism of the common element view of concepts, for there is in principle no reason why this concept formation theory could not, instead of speaking about elements or features, speak about the formation or abstraction of patterns or structures. A telling argument against such a shift, however, is that this would now require a description of such structures, or rather, of our knowledge of such structures. Such a description would presumably begin with a criticism of the 'common element' theory of concepts.

Ernst Cassirer (1923) considered the process of the abstraction of commonalities of features (however these were defined) from events, as a reduction, insofar as that which was merely a "part now comes to constitute the whole". That is, he argued that the "essence" or intension of the concept, as a subset of features common to events involves essentially a process of "subtraction." Furthermore, he argued that the formal characterization of the concept as the selection and retention of common features and the disgard all of other (accidental) features from among events, is illusory, and the present author would add, a methodological characteristic of the concept-formation paradigm. One does not logically lose particular features or properties, rather, one retains an abstract equivalent of them. Such abstract equivalents may be interpreted, for example, as non-terminal symbols in a grammar, for which variable terms can be substituted. Hence, any theory of concept formation, or rather conceptual abstraction, must consider the question of permissible variations of exemplars of concepts, rather than ignore these variations and selecting only those aspects constant for all exemplars. Thus, as Cassirer notes, this is analogous to our understanding of mathematical concepts that fully retain the determination of special cases. When a formula is made more general, one not only retains all the special cases, one can derive these from the formula, and hence, the formula is richer not poorer in content. The formula is not unlike a universal statement or law which, by virtue of the successive values which its variable terms can assume, contains all the particular cases over which it holds. The particulars are therefore derivable from the universal. The subtractive theory of concepts is in principle unable to derive the specific instances from the concept since information about particulars is lost. However a genuine abstractive view of concepts yields a very different conception of their nature. This is in largely due to the fact that concept formation research never addressed the question of the concept, rather, it focused on conceptualization as a process of inductive reasoning.

The abstractive theory of concepts, as put forward by Cassirer (1923, 1955) describes concepts as relational structures (see Lenneberg 1967; Minsky, 1963). That is, it attempts to comprehend exemplars under a set of rules or laws from which these in turn can be derived. Basically the notion of a concept as a relational structure considers all exemplars of the concept as a set of expressions. The concept itself is defined in terms of a set of primitive (vocabulary) symbols (both terminal and non-terminal symbols) and a set of rules of relation or combination. Sets of expressions are generated by the repeated application of the rules on a set of primitive symbols. The primitive symbols and the set of rules define the intension of the concept. Expressions which can be generated by the application of the rules on the symbols are exemplars of that concept, while expressions which cannot be so generated, are not. Such a generative system provides a structural description for each exemplar that characterizes the (surface) structure relations among the various terminal symbols in each expression or exemplar. In addition, such a system would similarly specify the relations among different exemplars belonging to the concept.

This description of the concept as a relational structure is admittedly vague at this point. However, there are several implications and some additional assumptions which permit a rather different perspective on the theory of the concept from that implicit in the concept formation paradigm. A description of these implications will make possible a further elaboration of the theory here proposed. The first implication is that the intension of the concept is now conceived of as an abstract relational structure which can explicitly generate exemplars. More precisely, it is the identity of this generating relation, which is maintained through changes in particular contents, that constitutes the specific nature or form of the concept (see Cassirer, 1923). Exemplars of the concept need not disclose any common features or content, such an occurence would merely constitute a special case, rather the concept is represented as a set of rules on the basis of which exemplars are related to each other. The concept is therefore not something psychologically substantive, rather, it is pure function that gives itself only in the product (exemplar) and vanishes with this product (Cassirer, 1955).

Second, the relational view of concepts defines the interrelations among exemplars belonging to a single concept in terms of derivability from a set of rules. This point is crucial, for exemplars of the same concept are 'related' to each other irrespective of whether they have any features or attributes in common. Hence, generality is not achieved by the rejection and loss of information, but rather proceeds by a process of encoding information into progressively more abstract form. Generality is achieved by going from particular to variable terms - by 'abstraction' - by making certain events special cases of more general (inclusive) laws. One does not lose features or elements. - 'subtraction' - rather all features are encoded as non-terminal symbols for which variable terms may be substituted. Generality is then correlated with more not less information, and 'particulars' are special cases explicitly derivable from the 'universal' formula.

Third, the relation between the concept and its exemplars is such that the concept is represented in each of its exemplars but not necessarily contained in or identical with any particular one of them. Just as a particular English sentence does not contain within it the intension of the concept "a grammatical sentence in English", or as the law is not contained in or exhausted by an enumeration of the individual cases subject to it, just so the intension of the concept is not defined by an enumeration of its exemplars - its extension (Elkind, 1969). It is, of course, precisely the identification of the intension of the concept with its extension - or the view that the universal is contained in each particular - which requires that the 'common element' theory of the concept focus on the processes of attention and discrimination to distinguish accidental features from 'defining' features in the exemplar. However, Cassirer makes the point not to confuse the law with that which is subject to it (or by the enumeration of its instances), for such an enumeration of instances (a list and connectives) lacks the generating principle which permits the characterization of the relation of individual exemplars as belonging to the functional concept. Essentially, the confusion between a list of exemplars as characteristic of the concept, and a relational structure which explicitly generates exemplars of the concept, is one of "experience error". The intension of the concept is determined by all the exemplars belonging to the concept as being variables in the abstract rule system. It is this rule system and not an aggregate or list of features that constitutes the core of the concept. The intension of the concept is genuinely abstracted from particulars in the sense that it is in connection with particulars that the concepts, as relational structures, are induced. The relational structure of a concept therefore restricts its membership to those exemplars that can be generated by the structure, and is not merely the intersection or sum of those features which are common to these exemplars.

Fourth, the problem of handling novelty or productivity from a relational structure theory of the concept, proposes that the organism attempts to discover regularities affecting events - regularities usually not characterizable from a common element point of view - and to induce from these regularities propositions about these events which go beyond specific experiences. The nature of this process of induction awaits clarification. However as a minimum, it is proposed that it constitutes the tacit construction of a relational (rule) structure that captures the appropriate regularities from these events, and hence has generality. In short, such a relational structure should generate expressions that go beyond the exemplars experienced which were the basis for the induction process, but expressions consonant with the relational structure or concept. Therefore, novel events are recognized as belonging to the concept to the extent that they can be generated from the acquired relational structure.

Finally, the relational theory of concepts postulates that experience with specific events is used to induce general rule structures or what elsewhere has been termed 'grammars', which capture the regularities among these events. What is learned is an abstract rule structure which can generate not only those events on the basis of which the structure was acquired, but also novel events consistent with the structure or concept. Hence it follows that it is possible to find that the organism cannot distinguish, once it has the concept, between those events which constitute the experiential basis for induction of the structure, from those events or exemplars which are derivable from the structure but are novel. Thus what is learned is knowledge *from* past experience but not necessarily *of* past experience. Hence, the relation between knowledge and experience is one of set to subset, which is the converse of this relation specified for a 'common elements' theory of concepts. In any explanation of this description of what is learned, it should be evident that attention, discrimination and generalization are necessary but not the truly creative or sufficient components of conceptual abstraction.

In summary, the relational theory of the concept maintains that concepts must be characterized as abstract relational structures which can explicitly generate surface structure expressions, or exemplars, which themselves are relational structures. More generally, these expressions are themselves concepts and hence any adequate theory of the concept will have to address an interrelated network of concepts defined with respect to each other (Quillian, 1967; and the suggested changes by Wilson, 1972). Furthermore, since an exemplar may be an expression of more than one concept structure, these structures must be specifiable at various levels of description. It should be obvious that such a conceptual structure or abstract conceptual code would be quite different from a TGG as proposed by Chomsky (1965), if for no other reason than that the former is contingent upon sensible experience, whereas the latter is conventional in nature (Derwing, 1973). Just what such a conceptual structure may eventually come to look like, given that various and perhaps numerous models are equally plausible for familiar human capacities, appears to be an open question, with the exception of the several restrictions noted previously (Frijda, 1972). In any case, it is not likely that research directed exclusively at establishing the micro-features (for example the 'rules') of such a conceptual system will prove very fruitful, particularly in view of the temporal parameters on short-term memory. Instead, experimental research directed at the limitations and capacities, assuming such an abstract conceptual structure, would appear to be more productive (Posner, 1969). However, from within another context, it may be that writing machine programs with recognition capacities may be equally heuristic in an attempt to understand 'cognitive' learning (Gunderson, 1971). However, it is only the former which will be considered in the following chapters.

CHAPTER 6

A MECHANISM CAPABLE OF CONCEPTUAL ABSTRACTION AND SOME REFLECTIONS ON SCIENTIFIC REALISM

What are the implications of this description of the relational theory of concepts for a description of the organism as a mechanism? Here, again, we have only speculations, but it is clear that many of the behavioral abilities of the organism such as attention, discrimination and generalization, will remain an integral part of such a mechanism. Nevertheless, the reconceptualization of the theory of the concept does have certain foundational implications. Craik (1943), among others who have worked from within an information processing paradigm, has suggested that a proper view of the organism or system in relation to its environment, is that it constructs an internal model, or unitary concept, of its world. Such a unitary concept or relational structure of its environment would not only capture the regularities of its world, and hence there is no implication that such a unitary concept need be entirely rational or consistent, but also provide the basis for dealing with new information (see Kelly, 1955). Similarly, Minsky has indicated that the organism has inductive abilities or "general-induction schemes" which permit it to construct general statements about events which go beyond its particular recorded experience (Minsky, 1963). In a sense the organism may be viewed only by analogy to Chomsky's and McNeill's "language acquisition device," as a "concept acquisition device" which must be capable of constructing a general rule system (or 'grammar') which subsumes the regularities encountered in its world and permits the 'prediction' of novel events which are determined instances or exemplars of these regularities.

(see Chomsky, 1968; McNeill, 1970a). The analogy may be usefully extended by suggesting that the organism's knowledge of its world may be viewed as a unitary conceptual structure, composed of numerous (sub)concepts, perhaps hierarchically organized or in terms of selected domains or "field" (Russell, 1967, p. 254), some of which are central while others are peripheral (for example Rokeach, 1968), or perhaps in terms of credibility or some other (non)cognitive attitude (Abelson & Carroll, 1965; Colby, 1965), which could be conceived of as the operation of some semantic relations upon others.

The notion that the organism constructs an internal model - to be sure a model of a particular kind, one that is entirely structural - of its world may be taken as the organism's 'theory' of its world. It therefore becomes the task of the theorist to construct a theory of the organism's theory of its world. That is, it presumably is the task of the theorist to make explicit the implicit structure of the organism's perceptions, beliefs, judgements, and intuitions of, and, actions in that world. Not only Cassirer (1953,1955) but also Craik (1943), Hayek (1952, 1969) and Chomsky (1968) have all pointed to the similarities between the organism's theory construction of its world and the theorist's theories about these. Already, Hayek made this explicit in the introduction to his 1952 monograph:

> The qualities which we attribute to the experienced objects are, strictly speaking, not properties of objects at all, but a set of relations by which our nervous system classifies them. To put it differently, all we know about the world is of the nature of theories and all 'experience' can do is change these theories (Hayek, 1952, p. xix).

That is, all knowledge as characterized by an abstract conceptual system is descriptive knowledge; knowledge by description as opposed to knowledge by acquaintance. Such descriptive knowledge is necessarily inferential, an abstraction *from* experience, and propositional, which is to say, relational (see for example Russell, 1967, Part 3, Ch. 7).

At this point it is well to digress and examine some ancillary considerations to the position presented thus far. The characterization of the theory of concepts has been predicated to 'organisms' under the assumption that the description is essentially accurate with respect to at least the species Hominoidea (Baker, 1974). Nevertheless, this assumption must be adumbrated by the minimal claim that descriptive knowledge is attributed only to organisms who have minds. This would seem a defensible position insofar as 'mind' is not introduced as a primitive term but as that still-to-be defined property of organisms responsible for its description. Certainly, it is only with respect to minds or mental states that the domain of cognitive psychology is distinguished from the study of (non-mental) 'behavior' more generally. Unfortunately, the array of entities subsumed under the notion of mental, such as ideas, concepts, associations, rules and still others, appear to contribute very little to its definition. More recently, the philosophy of mind has typically dealt with this problem by asking not, What characteristic entities are typically mental? but, Which descriptions of states (of the person) are mental? With some agreement it has answered this question with the grammatical sentence in the form of '$\underline{S}$ $\underline{\phi s}$ that $\underline{p}$' which is presumably the protype of mental descriptions (see Rozeboom, 1972). For this 'indirect quotation' a subject term is substituted for '$\underline{S}$', a verb for '$\underline{\phi}$', and a proposition for '$\underline{p}$'. The result is a sentence which is in accord with our intuitions about what mental states should be (for exceptions to the generality of this formulation see Rozeboom, 1972, and for its contrast to 'direct quotation' see Quine, 1960). Clearly, a large number of terms could be substituted for the verb, but in keeping with the etymology of 'cognition,' verbs such as perceives, remembers, believes, knows, thinks, and understands, appear respectably cognitive. This paradigmatic description of a mental state is one of knowledge by description, where the description may be true for a particular person even if the embedded proposition is false. This characterization of mental states by indirect quotation has been taken as evidence for the intentionality of psychological states, namely, that they point to something else (Chisholm, 1965), or are about something else presumably in the world of objects. Furthermore, the content of the psychological or mental state, that is 'p', has the internal complexity of a proposition which is a minimal requirement for a cognitive theory in order to be about states-of-affairs (Chapter 4, above).

What has been bothersome about the indirect quotation is precisely that it deals with organisms who have minds, language, and propositions or meaning. It is with respect to the latter that indirect quotations have been sharply distinguished from direct quotations where the speaker may be defined by the biological sciences and the sentence by a phonetic or semantic behavioristic analysis. Thus, Quine states that indirect quotations are more a matter of conjecture than description:

> An indirect quotation we can usually expect to rate only as better or worse, more or less faithful, and we cannot even hope for a strict standard of more or less; what is involved is evaluation relative to special purposes of an essentially dramatic act (Quine, 1960, p. 219).

While at the level of language or speech-acts these things may be tolerable, given that there is always the original (recorded) text to go back on, in the case of mental acts, as in perceptions, beliefs and memories (not to mention those ineffable states which cannot be verbalized), the fiction may be too grand. Hence, Quine and others have taken expressions of indirect quotation as being "... in striking contrast to the spirit of science at its most representative ...", which is to say, in contrast to the study of "... physical constitution and behavior of organisms" (Quine, 1960, p. 221). Here again we are faced with the behaviorists' critique of mentalism and its nominalist and associationist assumptions, which even Quine defends as an "admitted bias" on pragmatic grounds only (Quine, 1960, p. 238).

The difficulty is one that was previously addressed in this thesis: to acknowledge the indeterminacy of all indirect quotation without having to abandon the claim that any such description of knowledge is mere fantasy; rather, its instantiation is in some empirical space. Indirect quotation involves some 'deeper' condition of the person than anything that might be suggested by the utterance substituted for the proposition '_p_'. Not only is it maintained here that this something more or deeper is in the nature of concepts at the surface or perceived structure level, but that these concepts themselves have a structural description at a more abstract level. Even if the case for such a claim is presently one in principle, indirect quotation constitutes not only a harmless paraphrase, but one essential towards progress of a theory of cognition.

The present analysis of the theory of concepts is merely one that attempts to describe how complicated a system need be before one can ascribe to it meanings and hence mental states. In short, nothing less complex than a relational structure, or in the case of the grammar of a language, a context-sensitive grammar will be sufficient.

The thesis that knowledge as described by an abstract conceptual code is both an abstraction *from* experience and propositional in nature can be made more forceful if we acknowledge its adherence to an epistemology of critical realism (Armstrong, 1961, 1968) or structural realism (Maxwell, 1968, 1970). It is particularly the latter which is in focus here.

If our current theories of physics, neurophysiology, and psychophysiology are correct, then a complete causal account of knowledge, as Bertrand Russell and others have argued conclusively it would seem, entails that such things as we common-sensically identify as belonging to the external world, including our own bodies, are strictly speaking unobservable and that our only knowledge is about their structural properties. In other words, the argument is that the properties that we ordinarily ascribe to external objects on the basis of direct perception, so called, actually do not belong to the object at all, but are wholly in the mind (see Eccles, 1953). For example, Russell states that

> The inference from experiences to the physical world can, I think, all be justified by the assumption that there are causal chains, each member of which is a complex structure ordered by the spatio-temporal relations of compresence (or of contiguity); all that the members of such a chain are similar in structure; that each member is connected with each other by a series of contiguous structures (Russell, 1967, p. 228).

The claim that all knowledge about the world is structural in nature will be examined in somewhat more detail below, but first we must understand the nature of this version of realism.

The common element theory of concepts, which was examined in some detail above, is the psychological equivalent of what is sometimes termed "concept-empiricism." As the name implies, it maintains that all concepts must originate in experience, or in more contemporary terms, that the meaning of all words which are not given explicit verbal definition must come from ostension. The historical antecedent for such a claim is exemplified in Hume's dictum that there "is no idea without previous sense impression." Any such idea is an 'abstracted idea' or a generic concept, one that is abstracted from perceptual impressions (or features) or is a generalization from these impressions via the principles of association. The philosophical doctrine of concept-empiricism has historically been conjoined with a strict confirmationism. The latter position is consistent with concept-empiricism, and maintains that all justified assertions are correct assertions to the extent that these are confirmed by experience or observation. It is logically not necessary to adhere to both concept-empiricism and strict confirmationism but certain versions of positivism and hence behaviorism have found both doctrines congenial. An important characteristic of this position is that the meaning or justification of an assertion resides precisely in its perceptual evidence and therefore meaning is decidedly arbitrary or rather entirely contingent upon the individual's history of associations among his perceptual impressions. This is not simply the claim that the relation between sound and meaning is arbitrary or conventional, but rather that the meaning or significance of linguistic signs, of generic concepts as composed of common features, is itself arbitrary. One reason for describing this "excessive form of empiricism" (Maxwell, 1968, p. 148), which restricts discourse to what is directly observable, is that it restricts the term 'to know' to what is known directly by experience, entailed by that experience or inferable by simple enumerative induction from such experience. Another reason is that it ignores arguments from neurophysiology and other sciences, namely, that a causal theory of knowledge cannot possible be about those experiential properties which we ordinarily ascribe to the external world. The latter are wholly properties of the mind and hence not public. It is perhaps the irony of a radical behaviorism that it should maintain both these positions, namely, that knowledge is only of that which is directly observable and that all such knowledge is inherently private (Skinner, 1953, Ch. 17). It is precisely the radical behaviorist's invalid inference from "behavior is what we observe" to "behavior is what we can know about" which permits the characterization of this position as adhering to both concept-empiricism and strict confirmationism. As Russell (1967) has pointed out, there is nothing irrational in restricting oneself to experience and logic and to refuse anything beyond observation, it is just that the sincerity of such a position is in doubt.

It should be clear that in this extreme form, the premises of concept-empiricism or strict inductivism consist of singular statements which are either totally about direct observables or have been confirmed on the basis of direct observation by simple inductive arguments, and also "... that the form of the simple inductive arguments insures that the conclusions do not refer to properties or kinds of entities unless they are also referred to in the premises" (Maxwell, 1970, p. 13; see also Quine, 1972). This makes confirmation of any statement referring to anything unobservable completely impossible, and hence the position of strict confirmationism often accompanies that of concept-empiricism.

Furthermore, the strict inductivist's contingent knowledge is restricted to whatever he takes his observables to be. If he takes his observables to be private experiences, he must accept some form of instrumentalism with respect to theory construction and confirmation, or else if he takes his observables to be in some sense public he will tend towards a position of direct or naive realism and most often some form of behaviorism. Hence he will deny any knowledge of private experience of others and those of his own.

The impotence of a strict inductivism, concept-empiricism and strict confirmationism for a logic of science is well documented (Quine, 1972), and the necessity for something like a hypothetico-inferential (hypothetico-deductive is too narrow a term since sometimes inference from hypothesis to evidence may be nondeductive or statistical; see Chapter 1) approach to the logic of scientific theory would remove much of the ground for opposing a causal theory of knowledge which adheres to realism. That is, hypothetico-inferential reasoning does not pose the same difficulties with respect to unobservables provided it does not adhere to a strict confirmationism which is sometimes evident in methodological behaviorism. For example, the primary reason for the behaviorist's rejection of a TGG, as a theory of competence, is that its rules are "... incapable of direct behavioral interpretation ..." strict confirmationism, and that therefore it is " ... inherently unlearnable ... " concept-empiricism (see Derwing, 1973, p. 310). On the other hand, the difficulty with hypothetico-inferential logic is that no matter how much evidence may accumulate (by observation or experiment), there will always be an indefinite large number of mutually incompatible hypotheses, each of which when conjoined with propositions expressing appropriate background knowledge will yield as consequences all of the evidence (see Rozeboom, 1970). In actual practice we do, of course, have success in selecting from among competing hypotheses which are on par with the evidence and logic, but then again there is often disagreement, disagreement which may span decades!

In the face of such disagreement, the principle of parismony is often invoked. However it would seem that there are no purely logical reasons for supposing that simpler hypotheses are more likely to be true or closer to being correct. It should be noted that this principle of parsimony, which Osgood invokes for his mediation theory of meaning (Osgood, 1968), has also been invoked by the transformational language theorists in an entirely *ad hoc* fashion with their appeal to the criterion of 'simplicity' as applied to grammars (Derwing, 1973, Ch. 5). In fact the transformational theory of language, with its central syntactic component, has become hopelessly complicated in the attempt to incorporate 'well-motivated' changes in the grammar which will include as many examples of possible utterances belonging to the language. In view of this consideration, the theory of grammar as put forward by Chomsky is purely instrumental without any hope of the unobservables ever becoming 'observable'. To maintain any position of realism with respect to the propositions in linguistic theory, one must begin with a cognitive theory of meaning - one it is true in a certain sense analogous to the structural claims made by a TGG - but one which is in principle contingent or rather one which is subject to evidence. Instead what has occured as the result of working under the banner of rationalism, or more concretely from the application of the "mathematics of symbol manipulation" (Pylyshyn, 1972, p. 548), is that a TGG has almost wholly divorced hypothetico-inferential reasoning from any 'ties' to the world. It is precisely for this reason that a TGG, or a theory of competence, can make existential claims and at the same time reject traditional empirical criteria of meaning. Now as was argued above, the freeing of hypothetico-inferential reasoning from both concept-empiricism and strict confirmationism is well justified. Concept-empiricism, even if it should adhere to a direct realism, faces insurmountable problems with respect to unobservable entities. It simply lacks the concepts to express knowledge about unobservables. Similarly, a strict confirmationism, given that it too adheres to a direct realism, lacks the forms of inference that permit it to confirm knowledge about unobservables (see Maxwell, 1962).

Yet, clearly, the rejection of excessive empiricism does not abdicate the theorist from testing his theories or making explicit the basis for his formulation of these. Inference to the best explanation is not a magical affair and our knowledge of the world is not innate. The role of observation in the scientific enterprise, while greatly overemphasized, remains crucial. However, observational evidence must be sharply distinguished from meanings or referents, and must not be interpreted so broadly as to include any reason for rejecting or adopting a theory or scientific statement.

With this in mind the question for a theory of cognition, which must necessarily be a theory about unobservables, but not about fictions postulated to meet some behavioral criteria, becomes a question about the extent to which such a theory can be reconciled with scientific realism. Russell, among others, has attempted to reconcile realism with concept-empiricism by making a distinction between knowledge by acquaintance and knowledge by description. His theory of descriptions is an attempt to demonstrate how it is possible to maintain his principle of acquaintance and also formulate propositions about entities with which we are not acquainted (indirect quotation). In brief, Russell claims that the only aspects of the non-mental world of which we can have any knowledge or any conception are purely structural or formal. The difficulty lies, of course, with the explication of the notion of 'structure'. Russell realized just how formidable the problem of formulating the notion of structure would be:

> A word acquires meaning by an external relation just as a man acquires the property of being an uncle. No post-mortem, however thorough, will reveal whether the man was an uncle or not, and no analysis of a set of noises (so long as everything external to them is excluded) will show whether this set of noises has meaning, or significance if the set is a series of what seem to be words (Russell, 1967, p. 251).

and similarly, once a structure was formulated, its limitations:

> ... an analysis of structure, however complete, does not tell you all that you may wish to know about an object. It tells you only what are the parts of the object and how they are related to each other; it tells you nothing about the relations of the object to objects that are not parts or components of it (Russell, 1967, p. 251).

Just what the ultimate units (including relations) of such a structure are will depend upon man's continued understanding of his world. In other words every account of structure is relative to certain units which are for the time being as themselves devoid of structure.

Russell provides a definition of structure which is quite in accord with the minimal requirements specified for a semantic structure above.

> ... structure always involves relations: a mere class, as such has no structure. Out of the terms of a given class many structures can be made; just as many different sorts of houses can be made out of a given heap of bricks. Every

> relation has what is called a 'field' which consists of all the terms that have the relation to something or to which something has the relations (Russell, 1967, p. 254).

At one extreme such a structure will be in terms of logic alone: logical connectives, quantifiers, and predicate variables and will contain no descriptive terms whatever. Essentially, the study of syntax from the perspective of TGG tends in this direction. It has been brought to the degree of abstraction where it can be pursued without reference to the external world. The analysis of grammatical meaning is logical or mathematical in nature and yet the mathematics "... are such as no pure mathematician would have thought of for himself" (Russell, 1967, p. 248). The application of recursive function analysis in the formulation of the phrase-structure and transformational rules of a TGG are wholly dependent upon an understanding and empirical investigation of the combinatorial properties of language. Indeed it may be argued that a TGG is nothing but one possible formalization of the empirical facts of a structuralist linguistics. It is true of course, that this particular formalization of grammar and the accompanying theory of language, brought back into focus the concept of 'rule' in contrast to Saussaure's system of 'elements' or the structuralist's 'items and arrangements' which, with the emphasis on 'creativity', made the application of recursive function analysis powerfully appropriate. Nevertheless the minimal vocabulary of the structuralists was no more extensive than that employed in a TGG. Hence, it is doubtful whether the actual understanding of language has increased beyond that recognized by pre-TGG linguists. It was precisely Russell's claim that every discovery of structure enables a reduction of the theory's minimal vocabulary required for a description of the subject matter.

> Any region in space-time can be defined in terms of its parts, but its parts cannot be defined in terms of it.
> If you wish to speak about complexes and about things which are in fact their constituents, you can always achieve it without names for the complexes, if you know their structure. In this way analysis simplifies, systematizes and diminishes your initial apparatus (Russell, 1967, pp. 258-259).

Certainly, Russell's understanding of structure was that it is factual or contingent, and in its exemplifications at least, concrete. Yet his understanding of the structure of meaning was neither linguistic, nor indeed conceptual in nature in the sense of referring to ideas which have corresponding expression in language. It is an objective feature of the world. Russell distinguished between two types of meaning structure. In the first case, he speaks of structure as composed of words or their equivalents for every thing, relation, quality and logical connective, a sense that requires no further analysis. Such a structure is essentially one of verbal or nominal definition and assumes all the complexity of a dictionary. Logically, it can only be this type of structure to which the nominalist (read behaviorist) adheres (see Kneale, 1969). This type of structure is similar to that proposed by Quillian and Shank. Instead, Russell prefers a denotative definition of structure which may contain certain constant signs (or names) for particular qualities or relations which cannot be further analyzed in terms of other qualities and relations, and proper nouns which require no names since they can always be analyzed in terms of certain qualities and relations and logical connectives (see Russell, 1967, Part 4, Chapter 4). This conception of structure is in some respects similar to that proposed by McCawley and Fillmore.

Whatever the description of the structure of knowledge may eventually be like, it must be clear that from a position of structural or critical realism, propositional knowledge or knowledge by description is always of higher order properties of events or individuals. That is, such an abstract structure contains neither names of events, nor names of features or properties of events, for such a description would result in an infinite number of purely conceptual or nominal constituents. Instead, as Maxwell has suggested, such an abstract conceptual structure would consist of existentially quantified predicate variables, certain logical terms and perhaps a minimal vocabulary whose referents are directly observable. Such a description does not tell us what the properties or classes are, in the sense that we cannot name them with constants or visualize them in terms of concrete imagery, rather such description exemplifies the contention that we cannot know the intrinsic nature of observables. What we ordinarily think of as names are better thought of as abbreviations for definite descriptions (Maxwell, 1968, p. 154 ff.). However, the claim is that we do know that these properties exist and have certain relations and attributes, and hence this knowledge structure is in accordance with Craik's claim that the mind or nervous system "... models the causally related physical world" (Craik, 1943, p. 46). It should also be understood that the traditional associative properties of temporal succession, simultaneity, and causal connection must be counted among these structural properties as special instances of relations. In summary, our knowledge of the world is entirely limited to its structural aspects, knowledge by description is of its higher-order properties, which may, or may not be isomorphic to the perceived structure of our knowledge by acquaintance.

The distinction between knowledge by acquaintance and knowledge by description permits a meaningful discourse about the world, how to confirm or disconfirm theories and hypotheses about it, even though we can never observe any portion of that world directly. It is not essential that sense impressions or perceptual experiences or whatever the content of the perceived structure, resemble the physical objects which may be among their antecedents. It is merely necessary to maintain that the contents of these perceptions themselves have structures to postulate a structural similarity between the perceived structure as isomorphic to the abstract structure. It is important to note at least one implication of this position of realism. It is what Quine has termed the "central plank" in the position of realism, namely, that " ... our knowledge of the external world consists in a sharing of structure (Quine, 1968, p. 161). What this structural thesis maintains is that " ... between two men's knowledge of the same things there is more substantial resemblance than between the knowledge and the things" (Quine, 1968, p. 161). This conjecture would appear to eliminate much of the difficulty surrounding the problem of the accessibility of other minds. Of course, with respect to the knowledge of other minds, we are usually not just concerned with descriptive knowledge, but are also interested in the perceived content of experience. Here the most reasonable guess is that others have experiences (knowledge by acquaintance) which are qualitatively identical to or at least similar to our own. While there appears to be no conclusive evidence for this, the evidence we do have is convincing from a practical perspective and theoretically compelling with respect to the contention that our knowledge by description is knowledge which is shared.

A caveat must be made with regard to phenomenal experience. It is not suggested that our knowledge by acquaintance is in some sense false or not to be trusted. Indeed, evolutionary considerations alone would argue for some kind of correspondence between private experience and events in the world. In fact, it may be argued that the experimental work in perception confirms the existence of correspondence between certain aspects of the stimulus or energy array and the perceptual experience. At least this would appear to be the case when the stimulus is defined in terms of an ecological order, as information or as invariants, as is proposed by Gibson (1966) who argues, on this basis, for an epistemology of direct realism (Gibson, 1967). On the other hand, when the stimulus is defined in terms of physics the correspondence immediately breaks down or at least considerable machinery has to be postulated to reconstruct such a correspondence. In any case, from the position of structural or critical realism, the invariants in the ecological order constitutes knowledge by description; knowledge of higher order properties. Thus the invariants of gradient and such transformations of shearing, wiping, perspective (Gibson, 1966) are clearly not *in* my experience even if I could be made aware of the effects of their absence.

In summary, from this consideration of an epistemology of realism, two implications are relevant to the relational theory of the concept. First, excluding a position of subjective idealism, it has been argued that our knowledge of the world is not in any sense directly observable or knowable, and hence verification, even in principle, appears to be a questionable criterion, one that belongs to an excessive empiricism. Knowledge (of the world) is not in any sense verified by experience, rather the quest is to set up conditions under which our knowledge can be appropriately exemplified in experience. While something like observational evidence can be gathered, given 'standard conditions' and 'normal observers', in support for a scientific hypothesis, the crucial point is that this is an 'evidential' base only, and that the events and relations which constitute the referents of most observation terms are not publicly observable. These referents are part of the abstract structure and descriptions of states-of-affairs.

Second, in contrast to realism, instrumentalism has reversed our understanding of scientific theory. Instrumentalism maintains that scientific theories are instruments whose function it is to enable one to predict and explain observables; whereas structural realism would maintain that observations are for the most part instruments that provide the evidence for one's theory. Theory constitutes knowledge by description which is in no sense directly observable. Hence in contrast to concept empiricism, which maintained that justified assertions are the only correct assertions, realism maintains that the correctness of an assertion is a matter of knowledge by description, that is, the correctness of the propositional complexity of 'ideas' or 'concepts' and not in the first instance of observational evidence.

This brief digression was not meant as a synopsis of the logic of theory construction and validation in the sciences, a task well beyond the scope of this paper. It was meant to point out that there exist parallels between one version of excessive empiricism as this may have been practiced and certainly can be applied in the scientific enterprise and the common element theory of concept formation as this is understood within psychology.

These parallels are not surprising of course, since the origins of empiricism, as found for example in Bishop Berkeley's *New Theory of*

Vision, 1709, (Turbayne, 1963), were in fact proposed as a psychology of mind. In any case it is not crucial to the argument presented here whether anyone ever seriously held either concept-empiricism or strict confirmationism as sufficient for the logic of science. What is important to the argument for a relational theory of concepts are the following three claims. First, that theories are more than statements enumerating a series of events, rather they are statements that characterize or capture recurrences of events and have the capacity to predict and/or incorporate novel recurrences of events. Second, that a theory achieves conceptual clarification by the abstraction *from* a particular mass of observations and from a particular theoretical point of view. Whatever the precise formulation of this admittedly complex process, one thing is certain, that not all possible theories are proposed and it is indeed the genius of the theorist that he is able to exclude or discard certain hypotheses from his investigation. Third, the question of competing theories appears not to be solely decided upon, if at all, by observational evidence, but appears to be more dependent upon the explicit or implicit theoretical preconceptions of the theorist. Thus while it is important not to equate the logic of scientific theorizing with the organism's developing understanding of its world, there are certain striking parallels between the organism's 'theory' of its world and the theorist's theory construction of these.

The relational theory of the concept requires of the organism the capacity to construct an internal model or 'theory' of its world, one which cannot be simply characterized as a list of experiences, but one which must be seen as an abstract generative system induced from experience. Such a knowledge acquisition system may be conceived of as similar in kind to the speculations for a language acquisition device as proposed by Chomsky, McNeill, Fodor and others. However, whereas the structure of a language acquisition device appears to have been well advanced by a theory of transformational generative grammar, the structure of a knowledge acquisition device or theory of cognition appears, as yet, only in terms of the grammatical categories of ordinary language, that is, a theory of cognition which remains entirely phenomenological.

Indeed, as a first approximation, the organism's knowledge of the world may be characterized as a bounded set of inter-related, hierarchically organized concepts, which permits the construal of knowledge at various levels of abstractness depending upon the demands of the context. On the basis of grammatical categories one can logically establish an elementary vocabulary of the various distinguishable classes of concepts: of objects, of properties of objects, of transformations that objects can undergo, and relations that objects can enter into, of properties of transformations and relations, and perhaps others. Logically, these concepts all appear equally important in any characterization of the organism's knowledge of its world. However, psychologically, it may be argued that the concept of object appears developmentally prior to any of the others (Piaget, 1954). Presumably the psychological significance of every object concept is a function of the type of relations it can enter into with other classes of concepts including other object concepts.

A brief look at object class concepts convincingly demonstrates that objects are indeed concepts. Thus, perception of events is not tied to the flux of impressions or sensations at either the receptor or cortical level, rather the organism necessarily (tacitly) formulates the notion of the single object on the basis of experience with the transformations that leave it invariant (Gibson, 1966, Vernon, 1968). That is, the concept of an object entails knowledge of the various appearances that an object can take, and the implied "cognitive value of perception" (Brown, 1956; Bruner, 1957) is defined relative to the range of values the variables (relations and attributes or properties) of the object can take on. Cassirer (1944) and more recently Gibson (1966) and Elkind (1969) have all emphasized that the object as concept must be understood or defined relative to the transformations that leave it invariant. Constancy and change are mutually conditioned. The claim is that any characterization of what the organism knows when it perceives, comprehends, recognizes, or recalls some object must include the various transformations which the object can undergo and yet remain that object. Similar considerations obtain for class concepts. Presumably there are a larger number of variables and range of values that these variables can take on which leave objects members of a class concept.

Macnamara has recently pointed out with respect to the acquisition of vocabulary names, that children have a differential set to attend to varying states and activities rather than to the unvarying attributes of entities and hence the order of vocabulary learning would be as follows: " ... names for entities, names for their variable states and actions, and names for more permanent attributes" (Macnamara, 1972, p. 4). Similarly, he points out that while children acquire names for both object concepts and class concepts ['truck' versus 'toys'], it takes some time before 'truck' is understood as belonging to the class concept 'toys'. Presumably the child must acquire a more extensive vocabulary for entities, relations, and properties before the cognitive structure acquires the kind of flexibility in retrieval which enables the child to accept exemplars of the class which have no necessary perceptual elements is common. In this regard it seems likely that children initially take the main lexical items in the sentences they hear [nouns, verbs, and adjectives], determine the referents for these items and then use their knowledge of the referents to decide what the semantic structures intended by the speaker must be. That is, the child attempts to construe the meaning on the basis of his experience with the world. It may furthermore be argued that these various attempts at meaning construal form the basis for learning the syntactic devices which are correlated with the semantic structures (Macnamara, 1971a, 1972).

Recognition that the meaning of objects and classes of objects are a function of the various kinds of relations these can enter into (for example, spatial, causal and temporal relations, Wilson, 1972; Shank, 1973), reiterates the contention that concepts can have very different meanings and yet have exemplars which appear very similar (perceptual and semantic ambiguity), and conversely, that concepts can have very similar meaning and yet have exemplars which are very different (perceptual and conceptual 'constancies'). Analogously one can eventually speak of concepts of concepts and classes of concepts which have no particular existence in the world. This is to say that the meanings of many concepts have no particular form or content and their meanings are specified only in terms of the possible relations they can enter into with other concepts or class concepts. For example, following Fodor:

> When we identify a certain mousetrap with a certain mechanism we do not thereby commit ourselves to the possibility of saying in mechanistic terms what all members of the set of mousetraps

> have in common. [This would be the common element viewpoint.] Because it is roughly sufficient condition for being a mousetrap that a mechanism be customarily *used* in a certain way, there is nothing in principle that requires that a pair of mousetraps *have* any shared mechanical properties. Is is indeed, because "mousetraps" is functionally rather than mechanically defined that "building a better mousetrap" - that is building a mechanically novel mousetrap, which functions better than conventional mousetraps do - is a reasonable goal to set oneself (Fodor, 1968, pp. 115-116).

> Every mousetrap can be identified with some mechanism, and being a mousetrap can therefore be identified with being a member of some (indefinite) set of possible mechanisms. But enumerating the set is not a way of dispensing with the notion of mousetrap; that notion is required to say what all members of the set have in common, and, in particular, what credentials would be required to certify a putative new member as belonging to the set (Fodor, 1968, pp. 116-117).

It should be noted that not all possible objects can enter into all possible relations with other object concepts. The relational structure is essentially bounded. These bounds are not only a necessary characteristic of a meaning structure which is contingent and progressively conventional, but without bounds on its relational structure the organism would be confronted with an essentially random world.

Before examining the implications of the relational theory of concepts for a mechanism that can acquire such a relational structure, I should briefly consider the relation of concepts to language. First, it is consistent with the characterization of concepts that individual words do not refer to, or that sentences do not signify individual experiences. Rather individual words and sentences have as their referents concepts, usually class concepts, and concept complexes or propositions respectively. As the classes of concepts were chosen on the basis of grammatical categories, we should expect that the major classes of concepts correspond to major grammatical categories. Thus object concepts are expressed by nouns, properties of objects by adjectives, transformations that objects can undergo by intransitive verbs, properties of these transformations by adverbs, and the relations between objects and other objects by transitive verbs and prepositions. The meaning of a word or a sentence is exhausted by a characterization of the concepts and concept complexes to which these refer. Take as an illustration the object concept expressed linguistically by noun phrases. Such concepts are characterized as relational structures which specify all the possible relations that such an object can enter into. As a noun the word does not designate any particular relation, rather all the possible relations conceivable within a particular language community. Placing the object in any one particular relation defines a proposition which corresponds to placing a noun within a particular linguistic context which defines a sentence. While there is probably no such simple correspondence between concepts and language, something along these lines must surely be the case.

If it was correctly argued above that our understanding of the world at a perceptual/conceptual level is never confined to the particular moment but always involves the perception or understanding of events, it may be further argued that it is precisely from these perceptual/conceptual propositions that one acquires the meaning of concepts. In fact the relation between the perceptual proposition, or the perception of an event, and the concept is analogous to the relation between the sentence and the word respectively. The original element in language, as many have argued, is not the word but the sentence, or at the a-linguistic level, the proposition. Thus we should note that the meaning of each lexical element or word in the sentence refers to a concept but that the sentence as a whole does not. The sentence is expressive only of particular relations that objects can have with other objects. Predication always specifies only a subset of all the possible relations which the object (concept) can have with other objects. A complete characterization of all the possible relations that the objects can have with other objects would designate its full concept. The specification of any one particular relation would nominally be a sentence and, conceptually, a proposition. Whether at the linguistic or conceptual level these particular relations are what one commonsensically refers to as an 'idea'. It may be similarly argued that at the perceptual level, the perception of events, or states-of-affairs that are structured, are perceptual propositions or ideas! It is the characteristic of language that it permits both the expression of specific relations among events that are known (by description) for which there is no necessary (possible) corresponding perceptual basis, and the communication of this knowledge, by virtue of the fact that language is about concepts and concept complexes, the structure of which is shared within a particular social community.

Ideas are important for any system which claims that knowledge may be described as an abstract conceptual code whose output consists of concepts. Since the meaning or structure of concepts is a function of the possible relations their exemplars can enter into, our knowledge of these relations derives primarily from ideas. It is only because objects or particular events are perceived or defined in a variety of natural or permissible contexts, that is perceived or understood as ideas, that we can induce from these ideas events as members of the object concept or class concept. Similarly, it may now be argued that for many concepts and in particular those concepts that are abstract in the sense that they have no specifiable perceptual content, the exemplars are necessarily in the form of ideas. Such 'abstract' concepts are really concepts of concepts (or propositions about propositions) and their acquisition and usual exemplification most likely requires more than a single idea, perhaps sets of ideas the length of paragraphs or books.

The proposal that concepts derive their meaning from propositions and words their meaning from sentences and that the latter have as their meaning the former is quite consistent with a distinction between meaning and language (see Piaget's view and an extention thereof in Furth, 1968), without adhering to any functional separation of language and thought. The thesis is also supported by the developmental work in language acquisition which maintains that the development of thought is at first independent of language and that the infant uses the former as a clue in the learning of the latter. That is, the study of non-linguistic cognitive principles appears fundamental to the study of the acquisition of language and fortunately quite independent of contending grammars (Bloom, 1970; Macnamara, 1972).

Given that relational structure is minimally somewhat like the characterization provided above, we must now inquire as to the kind of mechanism it would take to acquire concepts and ideas. That is, we must specifically consider the relation between the intension of a concept and its exemplars or its extension. First, consider that the intension or meaning of a concept is never exhausted by an enumeration of its exemplars nor does the intension reside in any one exemplar. Second, since concepts, defined as abstract relational structures, are acquired and elaborated from experience with exemplars, it is suggested that any mechanism must be able to use information from temporally disparate experiences in the construction of concepts. Third, evidently not all the information present in these exemplars is retained, just that information which necessitates an elaboration of the structure to the extent that it will elicit assent of 'understanding' the exemplar. That is, specific exemplar information may not be available for recall (retained), as the content of the perceived structure or the knowledge by acquaintance is as transient as the stimulus input. In fact, most such exemplar information is probably not retained. What is retained is knowledge by description, an abstract relational structure, which permits the explicit generation of exemplars that are consonant with the acquired structure and the recognition of novel events as exemplars of that which is known. Now, clearly some experiential content is retained and sometimes for long periods of time, however, little more can be said about that here other than to take this into account in the experimental work to be reported later in this paper.

The first requirement of a mechanism that abstracts knowledge from experience is that it must be able to 'integrate' information from many temporally disparate but related events. That this must be the case is clear if we note that no particular event exhausts the meaning of a concept. Hearnshaw (1956) claims that the requirement of temporal integration involves the ability to form, from temporally disparate units, relational configurations which were never specified at any given time '*t*'. Indeed insofar as any event is an event experienced in time, duration must be considered a variable in the formation of any meaning structure. Many theorist have pointed out that temporal integration is a continual process in the transfer of information. Thus both Cassirer (1944) and Bohm (1965) consider temporal integration a requisite for the detection of invariant structure in the process of perception. Similarly, both Gibson (1966) and Neisser (1967) have made the point that temporal integration occurs not only across short duration intervals but across long duration intervals involving episodes and whole sequences. Indeed, the phenomenon of temporal integration has been thought to be impaired in the clinical syndrome of semantic aphasia (Goldstein, 1948, Ch. 3). Hearshaw (1956) has noted that sentence understanding, or, in Goldstein's terms, the ability to "propositionalize", involves the formation of contemporaneous patterns of meaning from units which are serially ordered and in temporal succession (see also W. Wundt in Esper, 1968; Blumenthal, 1970). Finally, it should be noted that there is no reason to restrict the temporal integration of information to information experienced consecutively since new information may affect the meaning structure in the classical process of assimilation.

The process of temporal integration is one requirement for a mechanism of concept formation, however it is clearly not a sufficient requirement. Not all information is integrated and contiguity is merely one relation among others. Just what determines which information is integrated presumably depends upon the existing structure of knowledge and upon certain environmental and possibly structural demands and restrictions respectively. Temporal integration is effectively a 'constructive' process which invests new experience with previous knowledge and hence "unites the present with the past" in a process which Barlett has termed the "effort after meaning" (Bartlett, 1932). Conversely, the constructive process of assimilation of new experience by investing it with previous knowledge also involves the elaboration of the knowing structure in a process of accommodation.

The claim that both learning and memory involves the constructive integration of information from temporally disparate experience implies that particulars are never experienced as 'existences' but are always understood as exemplars of concepts. It is with respect to these two requirements that we examine some of the experimental literature in the next chapter.

CHAPTER 7

A SELECTED REVIEW OF THE LITERATURE ON THE ACQUISITION OF MEANING

The relation between language and the structure of memory confronts the investigator with two distinct problems: The question of the structure of what is learned and retained, and the question of the structure of what is known, spoken or done. The term 'knowledge' has been applied to both these notions. However, these two questions about structure must be clearly distinguished if for no other reason than that the 'perceived structure' is phenomenologically available to the person, whereas the 'abstract structure' is a theoretical construction of the theorist and not open to phenomenal inspection. The abstract structure has been discussed at length in the preceding pages and it is further proposed that this representation of knowledge is essentially neutral with respect to the various modes of input and output (perceived structure). However, insofar as the abstract structure of knowledge, which is educed from the perceived structure and has the latter as its cognitive output, is propositional in nature, the organization of memory must be such as to permit the retrieval of knowledge in propositional form whatever the context of experience.

Attention to organizational variables in memory dates from the work of Ebbinghaus (Ebbinghaus, 1886). However the peripheralist focus in verbal learning research has precluded any concern with the structure of the material to be learned and hence with organizational factors of memory (see Tulving & Madigan, 1970). Instead, research and explanation has adhered to the single classical construct of 'association' among 'traces', 'ideas', 'images', or internal representations (of these) of stimulus and response terms. The latter consisted more often than not of nonsense syllables or single lexical items, since it was generally assumed that whatever organization was discovered in this manner would also hold true for sequences of syllables, words, sentences, and continuous discourse. Associations were variously conceived of as dispositions which, when appropriately activated by a stimulus term, would elicit a response term (Rozeboom, 1965). As Bower maintains in a review of this literature, "... the investigators of verbal learning do not interpret their results in terms of theoretical concepts ... the theoretical heritage of research ... has been ... functionalism ... and the analytic framework of stimulus and response associationism" (Bower, 1967, p. 182). This research, insofar as it has used linguistically meaningful material, has concerned itself primarily with inter-item relationships and item features. Thus it has unravelled two types of organization: associative and category clustering. Associative clustering refers to the chained elicitation of associates during free recall (see Deese, 1965; Deese & Hulse, 1967), and category clustering refers to the sequential organization of items, related in some way, during free recall (Bousefield, 1953; Mandler, 1966). Postman has suggested that " ... associative clustering appears to reflect directly the associative structure of words in a list and no recourse to mediational process is compelled by the data ... [whereas] ... some form of category clustering strongly suggests mediation by cue producing responses" (Postman, 1964, p. 180). Similarly, Cofer (1965), in contrasting these two types of organization, suggests that the opportunity for categorization enhances the amount of clustering to a greater extent than is common if association were operating alone. Thus he found the sequential recall for pairs of semantically related items superior to sequential recall for pairs which were not so related when both pairs were controlled for overlapping associations.

Whether these two forms of organization are distinct depends in part on one's understanding of the concept of 'association'. Thus, contiguity as an explanation (a necessary condition) of associative clustering itself requires explanation probably with reference to some notion of similarity of function, as this is part of the demand characteristics of the experimental context. In any case much of this literature has so severly restricted the possiblity of structuring the stimulus material, or rather used material with so little structure, that it has precluded the demonstration of any potential structure in retrieval. Hence, the abstract structure of memory has remained identical to the perceived structure with the addition of certain primitive terms such as 'association' and 'category'.

However other organizational factors than inter-item associations or associations among item features have been implicated in the learning-memory process. Thus the sequential structure or 'approximation to English' assumes that there are word order constraints on the organization of sequential material (Deese & Hulse, 1967; Miller, 1951; Miller & Selfridge, 1953). This variable is confounded insofar as the degree of approximation to English increases both the meaningfulness of the material in terms of semantics and syntax and presumably the inter-item associative strength (see Johnson, 1968; Yngve, 1960).

From within the context of linguistic theory there has been considerable research on 'grammaticality' as a variable in memory organization (Epstein, 1961, 1962, 1963; Johnson, 1965, 1968; Marks & Miller, 1964; Martin & Roberts, 1966; Martin, Roberts, & Collins, 1968; Mehler, 1963; Miller, 1962b). Generally, with respect to such dependent variables as speed of learning and accuracy in recall, it is found that there are consistent differences between grammatical and various degrees of ungrammatical material. However, with the exception of a study by Marks & Miller (1964), who found that grammaticality and meaningfulness were of similar magnitude in their effects on learning sentential material, the absolute difference between grammatical and ungrammatical material appears to be small compared to the difference between semantically anomalous and meaningful material where both of these are grammatically correct (Deese, 1970; Slobin, 1971).

In fact the concerted effort to demonstrate that the grammatical descriptions of linguistic theory have empirical content as exemplified in sentence memory and recall - the 'correspondence hypothesis' - has been largely abandoned (Baker & Prideaux, 1973; Bever, 1970; Fodor & Garrett, 1966; Watt, 1970). Indeed, Fillenbaum has pointed out that the failure of the correspondence hypothesis is probably due to the confounding effects of memory, which suggests that the manner in which knowledge or meaning is organized in memory may be very different from the grammatical organization of this meaning embodied in sentences (Fillenbaum, 1970; 1973). The organization of both the meaning import of grammar and semantics appears one that is difficult to make from a psychological perspective (Baker, Prideaux & Derwing, 1973; Schlesinger, 1971). Thus Baker, Prideaux, & Derwing (1973) speak of both the semantics of syntax and the semantics of content. That is, both the content of lexical items and their relationship to other lexical items (whenever these occur within the sentence or beyond it), serve a semantic role in communication. These authors go on to point out that in those studies which rely on memory and recall of contextless sentences it is not surprising that the semantics of content is better recalled than the semantics of syntax, for at least lexical items retain their meaning while syntactic patterns, which lack any particular association with lexical items and any pragmatic function in a contextless situation, are forgotten (see Sach, 1967). It is generally the context within which sentences are presented which provides the necessary link between the semantics of content and the semantics of syntax. Users respond to linguistic structure, at whatever level, inescapably in terms of its possible meaning, even if this is the degenerate meaning of contextless, non-grammatical, or anomalous sentences. Thus even where one controls for the lexical content, the syntactic pattern is responded to in terms of the function of its semantic or cognitive significance.

The various attempts to relate formal grammars to the psychological (memory) structure of the speaker has disguised an important distinction between language as product and language as process (Derwing, 1973, Ch. 9). Thus the formal grammar is essentially based on an analysis of language as part of the perceived structure and there is little reason to suspect that such a formulation is descriptive of the necessary and sufficient conditions for the actual production of language particularly in view of the strictly interpretative nature of semantics. Baker, Prideaux, & Derwing (1973) suggest that, rather than adhering to the hypothesis that speakers remember semantics and forget syntax in the studies dealing with sentence memory, it is more accurate to say that semantic information is ignored (the semantic import of syntax) due to the fact that sentences are presented in 'vacuo' where syntax does not serve a distinguishing information function.

Certainly fluent speakers of the language must have available a mechanism which permits them to process a grammar, however, the implication of a decade of testing formal grammars as psychological structures, which assumes that syntax may be described independently of other aspects of language, is at variance with the results which indicate that linguistic stimuli are reacted to primarily in terms of their meaning which is both lexically and syntactially conveyed. Thus even where persons are forced to attend to syntactic patterns rather than the lexical content of sentences, the research suggests that they still respond more as a function of the semantic significance of the pattern than in terms of the syntactic properties of the pattern per se (see Baker, Prideaux, & Derwing, 1973).

Clearly, as linguistic theory develops from formal theory about the perceived structure of grammar to a theory about the abstract structure of knowledge, we may expect that the formal 'relatedness' of syntax abstracted from language as product will not be adequate as a description of the structure of knowledge.

However, it must not be thought that the role of grammar is necessarily secondary to that of semantics in comprehension, rather, syntax and semantics and possibly various other contextual systems such as intonation patterns (Crystal, 1969), are inextricably related in any characterization of the abstract meaning structure (Blumenthal, 1967; Blumenthal & Boakes, 1967; Perfetti, 1969). This appears to be the case when we examine the inadequacy of the various formal types of memory organization.

Thus the matrix ordering of word meanings, either in terms of common semantic dimensions (Osgood, Suci, & Tannenbaum, 1957) or in terms of overlapping or shared verbal associates (Deese, 1965), is simply not adequate to specify propositional semantic or meaning structures between sets of words or concepts which have not common associates or connotative meaning. Similarly, hierarchical list structures are inadequate since these, not unlike the common element theory of concept formation, are largely arbitrary (Pylyshyn, 1973a; Wilson, 1972). A more powerful form or memory organization is a content addressable network of definitional and conceptual relationships activated from various nodes simultaneously, as Quillian (1969) has proposed. Such a structure permits the generation of answers in propositional form and similarly the incorporation of information from sentences (Frijda, 1972). In this process it is unlikely that sentences are first parsed in a separate analysis in a manner anything like that suggested by a TGG; rather, as Shank (1972) has suggested, the grammar may serve simply as a "pointer" to semantic analysis. That is, the parsing is conceptually directed by the abstract structure or memory system as this has been activated by the prior (linguistic) context (see also Wilson, 1970). The person constructs a 'conceptualization' which consists of various concepts (including relations) on the basis of his experience with the linguistic form. As Shank suggests, "... this is like saying that one sentence can express many complete ideas and the relations among those ideas" (Shank, 1972, p. 556). Syntactic processing probably occurs in parallel with lexical processing, where the former relies primarily on a dictionary which specifies or generates both syntactic and semantic contexts for a particular word, and where the latter also consists of a dictionary of possible conceptual realizations of the word and its possible relation with other words. It seems unlikely that these two dictionaires are markedly different.

Of course, the expressive nature of language commonly implies that it has both a simultaneous and sequential form of organization. It was suggested by Miller (1956) that performance on a memory task was related to the number of units or "chunks" to be retained rather than to the information carried by each individual item. Similarly, the processes of encoding and decoding as postulated by Miller are consistent with the notion that the number of chunks of the sequential form of the sentence which may be retained in immediate memory is limited, but that the information conveyed by the sequential linguistic form may be recoded as ideas or propositions (other chunks) related to, or instances of, the abstract structure of long term memory.

Unknown or 'subjective' factors in the organization of memory have been repeatedly demonstrated to occur (see Tulving, 1968). However, explanations of these phenomena are usually in terms of the formal restrictions on the research paradigm. On the other hand, the revival of the "reconstruction hypothesis" (Neisser, 1967) considers the important process responsible for the subjective or reconstructive recall to be in the nature of the schema. Bartlett originally defined the 'schema' as "... an active organization of past reactions, or of past experiences, which must always be supposed to be operating in any well-adapted organic response" (Bartlett, 1932, p. 201). Neisser has re-interpreted this notion of schema as a cognitive structure which he defines as a " ... non-specific but organized representation of prior experience" (Neisser, 1967, p. 287). For Neisser the schema is the process by which constructive recall occurs. Therefore the schema is an explicit description of those memory traces of the processes by which the original experience was constructed - a somewhat opaque account of the abstract structure. Nevertheless, such an account is quite consistent with the minimum dual requirements that learning and memory involves the integration and construction of knowledge from experience.

It should be noted that Wilhelm Wundt (Blumenthal, 1970; Esper, 1969) similarly characterized language by its simultaneous and sequential structures. The idea conveyed by the sentence was considered to be a wholistic semantic structure upon which language imposed its sequential, syntactic and phonological form. Presumably the simultaneous or semantic structures are not constrained by the sequential linguistic form of the single sentence; rather, the former might be expressed or conveyed via sets of sentences in continuous discourse.

All this is in sharp contrast to both the verbal learning research with its focus on words or syllables, and psycholinguistic research which has concerned itself solely with such atypical conditions as degrees of non-grammaticality or semantic anomaly using sentential material. While psycholinguistic research has given primacy to the study of the individual sentence, the distinction between deep and surface structure, between abstract and perceived structure, and simultaneous and sequential structure, is quite consistent with the reconstruction hypothesis which may be applied to the memory of the meaning for sets of related sentences. Thus, not only individual sentences but sets of successively related sentences could contribute to a single or common wholistic semantic representation of meaning. Intuitively this would appear to be "the effort after meaning" evident in the attempt at comprehension of discourse. That is, persons do not learn and retain individual sentences nor individual semantic structures, as an interpretative semantics would have it (Katz & Fodor, 1963); instead, persons use information from various semantically related sentences, often removed in time, and any other related knowledge of their world, to construct wholistic descriptions of possible events. It is precisely research demonstrating the psychological reality of inter-sententially defined ideas which is pertinent as evidence for the relational theory of the concept presented above. Such research was initiated by Bransford & Franks (1971, 1972) and Franks & Bransford (1971) on the basis of an experimental paradigm first employed by Posner (1969 for a review). It is this research which is examined below.

It has been part of this thesis to maintain that the full richness of stimulus experience is not usually retrievable from memory. Particularly in the processing of linguistic material even that stimulus material which is routinely processed may lose its specificity as more abstract and hence general classifications are achieved. Thus syntax, word order, intonational patterns and even individual lexical items are processed to the extent that their 'semantic' import contributes to an understanding or meaning of the message conveyed. This does not mean that information is lost, although some information regarding the form of the message probably is lost. The meaning of the message or utterance is retained as an elaboration of the existing cognitive structure of memory. The understanding of linguistic form exemplifies the assumption that all understanding of stimulus patterns assumes the availability of stored information.

While there are probably stages in the encoding process which do not require the availability of past experience (Hochberg, 1968; Posner & Mitchell, 1967), as encoding proceeds centrally or becomes in some sense more complex, past experience is necessarily brought into contact with new stimulus input. Certainly at the level of meaning or knowledge, past experience is always involved. Whereas the psychological nature of this encoding process is probably not best thought of as a serial chain, it may be logically conceived of as a successive process of abstraction which begins with elementary perceptual pattern structures and goes through to semantic or cognitive structures. This process of increasing abstraction of information requires both selection and classification. Now the term 'abstraction' has been used in two different senses in the present paper.

One sense of abstraction involves the selection of certain aspects or features of the stimulus array and the retention of common elements and elimination of differences from among separate experiences. This sense of abstraction has been applied primarily to visual stimulation where particular stimulus attributes are selected from among other attributes in accordance with the standard concept formation paradigm and the common element theory of the concept. The second sense of abstraction does not refer to the selection of particular stimulus attributes; it refers to the relation between particular experiences as determined instances or exemplars of concepts. This sense of abstraction has been studied with respect to both visual patterns and linguistic forms where the cognitive structure is elaborated as a function of the relation between information input and information in memory. This is what was referred to above as the relational theory of the concept. Posner (1964) has suggested that this process of abstraction may be thought of as one of information reduction which produces encodings of increasing generality. In a certain sense this is correct provided that the structure of even the most general encodings permits the recovery or retrieval of more specific information, that is, so long as the abstract representation of what is learned and retained permits the generation or enumeration of specific instances (see Selz in Mandler & Mandler 1964). The method of studying abstraction and the subsequent generation of instances involves minimally the recognition of identity (same states-of-affairs). The recognition of identity, which was considered by John Locke (Reeves, 1965), for example, as a basic cognitive operation, has the methodological advantage that regardless of the complexity of the cognitive operations involved in the decisions, the output requirement can be simply in the nature of a binary choice.

When one moves beyond the stage of physical or analogic simultaneous pattern matching (Posner & Mitchell, 1967; Posner, Boies, Eichelman, & Taylor, 1969) and begins to make use of stored information in recognition one is immediately faced with the inadequacy of the common element theory of the concept. Thus, "How is it that (knowledge of) different experiences are stored in a way that provides for the economic use of finite memory?" (Oldfield, 1954; Oldfield & Zangwill, 1943) and, "How is stored information used in pattern recognition whatever the nature of these patterns?" (Uhr, 1966). These questions are about the capacity of the mind to abstract from temporally separate individual experiences a composite representation which permits the recognition of novel instances or exemplars of this representation. So phrased, these questions are consistent with those put forward by the relational theory of the concept presented earlier. However, it was apparently Henry Head, the neurologist, who first recognized the importance of a representational system for storing information which took account of individual perceptual experiences but which was not identical with any set of these (see Riese, 1965). And it was Bartlett who took over Head's notion of representation and employed the term 'schema' as refering to the process of the formation of this representation (Oldfield & Zangwill, 1943). Oldfield (1954) attempted to make explicit the notion of the schema and suggested that it represented both the commonalities from among successive stimulus presentations as well as the departures that were characteristic of individual instances. Essentially this characterization constitutes and extension of the common element theory of the concept by representing significant departures of particular experiences in addition to their commonalities with other experiences.

Studies using as their paradigm this notion of the schema have employed as their task the perception of random visual dot patterns (see Posner, 1969 for a review). The basic pattern is termed the prototype and departures or deviations from this prototype are constructed by applying either stochastic changes or systematic operations on the prototype. The prototype represents the central tendency of the various deviations. *S*s are clearly able to identify deviation patterns that are instances of different prototypes or central tendencies (Posner, Goldsmith, & Welton, 1967). However, the prototype, as the central tendency of all the deviations from it, is unique in comparison to any of the deviations in that pre-training on the prototype is more effective in facilitating learning of the deviations than pretraining on any one of the deviations (see Attneave, 1957). Posner & Keele (1968, 1969) attempted to investigate directly the role of the prototype in the recognition of novel deviations from it. Subjects learned to associate various deviations belonging to different prototypes with a single key press in a standard paired associate task. They were tested on a transfer task which consisted of the prototype which they had not previously seen, old deviations which they had seen before, and control patterns that belonged within the deviations range of the various prototypes but which were deviations not previously seen before. The latter were chosen so that their distance from the stored or experienced deviation patterns was approximately equal to the distance of the prototype from these experienced patterns. The difference between the prototype and the control patterns is that the prototype as the central tendency shares features that are common to the set of all deviations from it. That is, the prototype represents the commonalities from among the experienced patterns and as such constitutes at least one characteristic of the notion of the schema. The result of this work is that the prototype patterns are correctly classified significantly more often than the control patterns which have the same distance from the experienced deviations. Thus there would appear to be something unique about the prototype classification:

> This indicates that the process of classifying patterns does not rely solely upon the distance of the new pattern from the particular stored exemplar. Instead, it depends upon the distance of the new pattern from the category of stored information that represents all the exemplars (Posner, 1969, p. 66).

On the whole, prototypes which were never seen before were classified as well as the various experienced deviation patterns. Similarly, the prototype has a higher probability of being classified correctly than any of the new deviation patterns (control patterns). These results are consistent with the phenomenon of stimulus generalization except that it singles out the prototype as a unique pattern.

There are two broad alternative classes of explanation for these results. The first is consistent with the notion of schema construction. It suggests an abstraction process where, on the basis of experience with a number of deviation patterns or exemplars, an abstract structure is acquired whose variables permit a range of values and hence the derivation of deviation instances belonging to the schema (or concept) even if these were never experienced before. An alternative explanation would be along the lines of individual feature storage where recognition occurs through, or is mediated by, individually stored traces experienced previously probably with reference to their frequency of occurrence.

To distinguish between these two lines of possible explanation one might observe what happens to these individually stored patterns or to the schema over time (Posner & Keele, 1969; Strange, Keeney, Kessel, & Jenkins, 1970). These studies were similar to the one described above except that the time interval between learning and recognition was not immediate but extended to one week. The results indicate that the schema pattern or prototype was recognized at least as well as the experienced/stored patterns. Moreover, while these old experienced patterns underwent significant loss over the week's delay, the classification of the schema showed no such decay.

This is a remarkable finding! Posner, in commenting on it, suggests that the schema or prototype was classified or 'constructed' on the basis of information *from* the whole series of experienced deviations or exemplars. In addition, since the reaction time measures for the recognition of the prototype was no longer than for any of the old pattern deviations, it may be inferred that the classification of information about the central tendency which takes place during experience with these exemplars is not mediated by these exemplars during the recognition phase of the experiment.

The second characteristic of Oldfield's interpretation of the schema pertained to the learning and memory of information about individual deviation patterns. Clearly, there must be some memory which is specific for the experienced exemplars, otherwise it would be impossible to explain why old deviations, which constituted the basis for the acquisition of the prototype, are better classified than the new deviations although both old and new deviations were the same distance from the prototype. That is, these results require as an adequate explanation something more than the abstraction of a prototype or schema.

Attneave (1957) on the basis of his work with nonsense polygons suggested that *S*s in this type of a task also learn something about the variability or distribution of the possible exemplars. In other words something about the range of values which the variables in the cognitive structure or schema can take on. The variability of the deviation instances experienced during the learning phase may have two quite different effects. Thus it may vary the efficiency with which common features are abstracted or it may vary the criterion concerning which patterns may be classified as instances of the schema. Posner & Keele (1968) using random dot patterns presented *S*s with either low variability (tight schema) or high variability (loose schema) deviation patterns. Afterwards *S*s were asked to recognize new deviation patterns as belonging to one of four prototype schemas. The new deviation patterns had the same overall distance from old deviation patterns regardless of the variability condition. Results showed that *S*s exposed to the loose schema did significantly better in transfer than those *S*s to the tight schema. The authors argue that the result of learning the loose schema could affect the criterion *S*s used for the admission of new patterns as instances of one of the four prototype schemas. Hence what is learned are prototypes and criteria of distortion; the latter being a fixed permissible range of values for the variables in the prototype structure.

This notion for which there is no direct evidence is similar to that suggested in our discussion of the relational theory of the concept. What is suggested by Posner's research is that *S*s abstract a representation that is sensitive to the commonalities among experienced patterns and that such a representation has criteria of acceptance for novel patterns as belonging to the representation or schema. As such the schema is a construction from temporally disparate experienced events which functions as the basis for establishing the identity of novel events. Such a schema is clearly analogous to a cognitive abstract structure in that it contains more, not less information than the sum of individually experienced events.

What happens when novel visual dot patterns other than the prototype are presented for recognition? As was pointed out above, the reaction times for the recognition of prototypes was no different from those reaction times of the experienced exemplars and it was therefore suggested that the prototype was recognized (classified) directly and not via the stored (features of) exemplars. Posner (1969) cites research to the effect that the reaction times for novel patterns increases as a function of their distance from the prototype. Thus, for patterns that have never been experienced the efficiency of classification is a function of their distance from the prototype. This would suggest that their recognition involves an 'internal computation' to determine whether these novel deviations fall within the criterion of acceptability.

In summary, Posner concludes that there are three characteristics to what is learned and stored in the nature of the schema acquired. First, *S*s acquire specific information about individual patterns experienced during learning. There is no problem here that cannot be accounted for by a simple list structure of stimulus-response theory. Second, *S*s acquire some information about the common properties or rather the central tendency of the set of learned patterns. This is the prototype. However the acquisition of the prototype cannot be accounted for in terms of the traditional theory of the concept since it is clearly an abstraction from particular deviation patterns which have nothing in 'common.' Third, *S*s acquire some information about the possible permissible variations of patterns where these remain deviation patterns from the prototype. That is, *S*s acquire something about the permissible range of values that the variables of the schema structure can take on, or in other words, the possible transformations from the prototype that are permissible. This last characteristic is an integral part of the construction of the schema. These three characteristics are attributed to the schema which is considered the most general description of the structure of memory.

The level of processing that represents the central tendency and the range of variability may also be termed an idea or concept. In line with our theoretical discussion of these it may be postulated that their representation is abstract and neutral with respect to form of the stimulus input. Thus with respect to the perception of visual dot patterns, Posner reports that *S*s expressed the recognition of visual patterns in terms of verbal rules concerning the position of dots and the configuration of the pattern of dots. However, he also indicates that these rules were decidedly idiosyncratic and often there were no stateable rules at all (Posner, 1969, p. 73). It is likely that *S*s are able to report only on what is visually present given they have acquired the prototype and furthermore because of the stochastic nature of the visual dot patterns it is difficult to infer anything else about the representation of the schema.

Franks & Bransford (1971) attempted to remedy this situation by using instead of random dot patterns well structured spatial configurations of geometrical form and instead of statistical transformations used systematic discrete transformations (such as deletion, permutation and substitution) of these figures. In addition, in lieu of reaction time measures employed by Posner, these authors employed recognition confidence ratings. The results indicate that the highest recognition confidence ratings were given to the prototype (or to the 'base' as they term it) and that these confidence ratings decreased as a linear function of the number of transformations from the prototype or base. (This finding will subsequently be referred to as the "linear effect".) It should be noted that like Posner's work, the base was never presented during the learning or acquisition phase of the experiment. Further, the authors found that *S*s could not distinguish between the transformations from a particular base presented during acquisition and novel transformations belonging to the same base when both were presented during recognition.

These results using well-structured geometric patterns are consistent with the findings reported by Posner using random dot patterns. Franks & Bransford have put forward two possible explanations for their results. The first is that memory organization consists of a set of features and that the acquisition configurations are analyzed in terms of a set of such independent features. (The authors are prepared to leave the term 'feature' primitive.) In addition, information about the relative frequency of the occurrence of these features is also stored. Recognition ratings should on this account be a function of the stored frequency of occurrence of the features in any particular recognition configuration. This explanation is consistent with some version of the common element theory of the concept and more generally with any account of meaning in terms of features. It may be contrasted with the 'schema hypothesis' which postulates that what is learned is the prototype or base, which is an abstracted relational structure and includes the permissible transformations from the prototype. The minimal specification of memory organization is that the structure of the schema acquired permits the generation and hence the identification or recognition of novel permissible stimulus patterns. The authors put forward the suggestion that the prototype is analogous to a constituent phrase structure (of configurations and their relative positions) and that the transformations are permissible changes of the constituent phrase structure not unlike the deep structure with optional transformations to the surface structure in a TGG. This explanation assumes that *S*s perceive, learn, and retain the relations among the acquisition configurations that correspond to the transformation relations used in generating them in the first place (by the Experimenter). While the exact nature of the acquisition of the prototype and permissible transformations remains unclear, these must be available in the recognition of novel instances as evidenced by the fact that recognition confidence ratings were a function of equivalent transformation histories. However, the acquisition and functioning of the schema is not open to introspection as *S*s were unable to provide any reasons for their recognition ratings. Franks & Bransford (1971, Experiment 3) have attempted to evaluate the relative validity of these two explanations, the feature versus the schema model, by equating the acquisition and recognition configurations for frequency of features. The authors conclude that the schema is a more adequate explanation for their results; however, the results do not definitively arbitrate between the two explanations. In any case, if *S*s process information by a feature model (learning the frequencies of features), they must do so by recognizing the transformational relatedness as specified in the patterns.

Bransford and Franks have applied their experimental paradigm to well-structured linguistic material (Bransford & Franks, 1971; Bransford & Franks, 1973). In their initial study (Bransford & Franks, 1971)[2], *S*s were presented with sets of sentences (exemplars), where each set was generated from the principle $S \rightarrow (A)\ (B)\ (C)\ (D)$, where S is a single compound sentence which fully exhausts all the semantic relations contained in the four optional simple declarative sentences (A), (B), (C), (D). Each exemplar was generated by selecting and concatenating one or more, but never all four, of the optional simple declaratives. Subjects were later tested for recognition memory of the exemplars presented during acquisition, of novel exemplars (that is, concatenations not presented during acqusition) including the compound sentence consisting of all four optional declaratives, and of non-exemplars which violated the principle above by concatenating optional declaratives from across different sets. Bransford & Franks refer to each compound sentence consisting of all four optional declaratives as an 'idea' or 'concept'. However, to avoid confusion between the idea and its various exemplars (which are also ideas), we will refer to the idea as the 'theme' and the various exemplars as 'ideas'. Every acquisition list contains exemplars composed of one, two or three concatenations of ideas belonging to four different themes. The acquisition list is so constrained that no two exemplars from a single theme are presented consecutively. This also obtains for the recognition list. Bransford & Franks again contrast two views on the nature of what is learned and retained during acquisition. The first position maintains that *S*s will integrate partial meanings (exemplars) of semantically related sentences and construct wholistic semantic representations of the complete theme. The second position, which the authors in a later study attribute to what they understand to be the interpretative view of semantics (Bransford, Barclay, & Franks, 1972), is that *S*s do not integrate and construct a theme, rather they learn and retain only the information as presented in the single sentences (exemplars) experienced during acquisition. That is, *S*s understand the meaning of linguistic material in terms of a set of independent features and insofar as novel sentences contain these features (exemplars), or some subset of these features, they will be recognized as seen before. These two contrasting positions are similar to the ones presented earlier (Franks & Bransford, 1971; Posner, 1969).

What results may be expected given these two positions? The first position argues that on the basis of experience with sequentially presented exemplars *S*s will construct wholistic or complete semantic representations. In the paradigmatic case it means that *S*s will constructively integrate partial semantic meanings conveyed by successive but non-consecutively presented acquisition sentences (exemplars) into various themes. It is the wholistic semantic representation of the theme which is retained and not the individual sentences to which *S*s were exposed during acquisition. Hence, little or no information would be stored about the acquisition sentences (exemplars) which formed the basis for the construction of the theme. Similarly, the recognition confidence ratings should, given the results from the previous experiment using geometric forms, reflect the acquisition of this theme. Three specific predictions may be made from this position. First, given that what is acquired is in the nature of the theme, new exemplars presented during recognition should receive positive recognition ratings if they are consonant with the theme acquired, that is, if they are some concatenation of optional declaratives belonging to the theme. Second, novel sentences which are not consonant with any acquired theme, that is, are concatenations of declaratives from across themes, should receive negative recognition ratings since these are not consonant with any acquired theme. It should be noted that the ideas expressed in these 'non-case' sentences have been previously presented in the context of ideas consonant with a particular theme, but never in the context of ideas from across different themes. Third, old and new exemplars (sentences presented during acquisition - old sentences; sentences consonant with the particular themes but never presented during acquisition - new sentences) should receive similar recognition ratings since recognition is based on the abstracted themes and only to a lesser extent, if at all, on memory of specific acquisition sentences.

It must be understood that these predictions are not in the least trivial. Thus the prediction that *S*s cannot distinguish old from new sentences which are consonant with the themes acquired appears in direct contrast to the amazing accuracy of recognition memory for sentential material in a recent study by Shepard (1967) as well as for pictorial material (Haber, 1969). The crucial variable in these studies appears to be that none of the individual sentences or picture material were related, whereas in the Bransford & Franks paradigm both old and new sentences are consonant with the theme.

The feature model assumes that *S*s analyze the meaning of acquisition sentences into sets of features. The feature model would have difficulty in accounting for theme acquisition. However, it may be that such acquisition does not occur at all. In any case, all that would be retained is a set of features, or sets of overlapping features, based on an analysis of acquisition sentences. The feature model could certainly account for *S*s' failure to distinguish old from new sentences during recognition memory simply in terms of matching features. Presumably new sentences consonant with the theme would contain some features identical to those contained in the old sentences. The feature model could similarly account for the rejection (non-recognition) of non-case sentences which do not contain the acquired features. That is, sentences which are concatenations of ideas from across themes and hence not consonant with any one theme would contain relational features which were never experienced during acquisition. However the feature model would have difficulty with recognition sentences which expressed the entire theme. Certainly these theme sentences would contain all of the features acquired during acquisition but in addition would contain relational features never before specified. Under the assumption that features are stored for individual sentences, and hence not for those relational features between sentences, those sentences expressing the entire theme would be rejected. Were the feature model to store relational features between sentences as well, and to do this *S*s would have to integrate the features from among temporally disparate sentences, the feature model would be indistinguishable from the schema model. But then temporal integration would require the construction of wholistic representations and it is precisely this, admittedly vague notion, which distinguishes the two explanations.

It should be noted that it is possible to maintain a feature model and assume that the relational features among sentences are carried by syntactic markers in the lexicon. However, it has been argued above that it is more plausible that these relational terms are semantic and not syntactic in nature. That is, the cognitive abstract structure may specify relations which are not directly reflected in the sequential structure of the sentence.

Bransford & Franks, in three different experiments, report the following results. First, *S*s were unable to distinguish old sentences from new sentences which are consonant with the themes used to construct both these sets of sentences. That is, *S*s assigned positive recognition ratings to new sentences which they thought to have been, but which were not, presented during acquisition. Second, non-case sentences which were concatenations of ideas across themes and not consonant with any theme were rejected. That is, *S*s were sure that these sentences were not presented during acquisition. The third, and perhaps the most exciting finding insofar as it potentially distinguishes the two possible explanations concerns the relationship between the number of ideas expressed by a sentence and the recognition confidence ratings. Recognition confidence ratings were clearly ordered: sentences with four ideas (expressing the entire theme) were given higher confidence recognition ratings than sentences expressing three ideas, two ideas, and sentences expressing a single idea ("linear effect"). This finding is surprising since the sentences expressing the various entire themes were never presented during acquisition, yet it is these which received the highest recognition confidence ratings. (This result is presented in Figure 1, P. 149). However, it should be noted that if we permit the feature model an assumption to the effect that recognition ratings positively covary with the number of features from the stored list that are contained in the recognition sentence, then we can account for this "linear effect". As this is not an unreasonable assumption we potentially have a feature model which can account for the data.

However, the authors clearly find in favour of the schema explanation. Thus the data are interpreted that *S*s acquire something more general than a simple list of sentences (or features) experienced during acquisition. Subjects integrate information conveyed by sets of individual sentences to construct wholistic semantic ideas or themes. Recognition memory was a function of those themes. Not only did *S*s fail to distinguish old from new sentences and reject non-case sentences all of which may be consistent with a feature explanation, but their recognition confidence ratings were a linear function of the extent to which these sentences exhausted the meaning of the theme. This finding

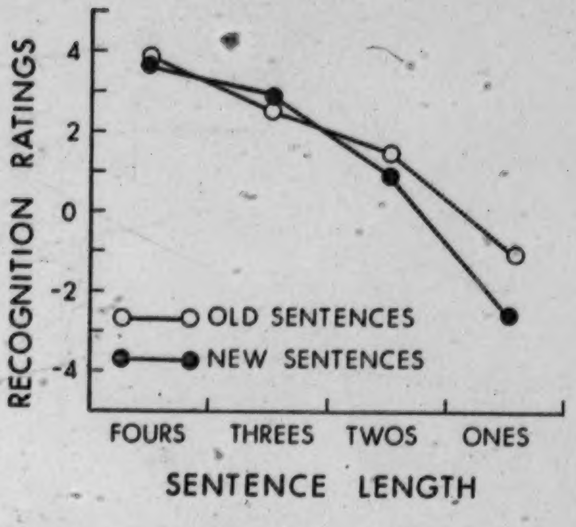


Figure 1. Recognition confidence ratings for old and new sentences of various lengths, (from Bransford and Franks, 1971, p. 346).

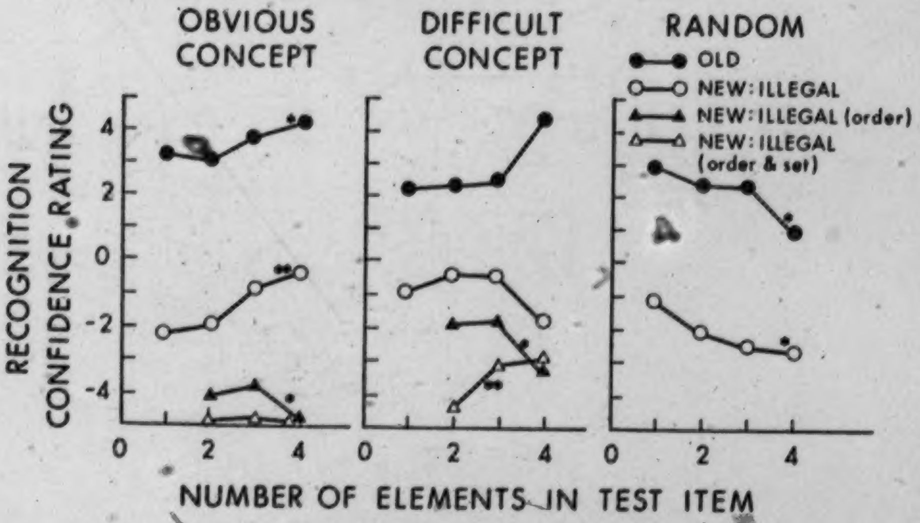


Figure 2. Recognition confidence ratings for old and legal and illegal items of various lengths (from Reitman and Bower, 1973, p. 199).

is particularly important since the high recognition ratings for sentences expressing the entire theme as well as for some sentences expressing the concatenation of three ideas can only be accounted for if one assumes that *S*s integrate information across various acquisition sentences experienced non-consecutively in time. What is learned and retained is in the nature of an abstract structure (theme) and it is on this basis that *S*s assign recognition confidence ratings. Thus it is not surprising that *S*s cannot distinguish old from new sentences when both are consonant with the acquired theme and that their confidence ratings reflect the degree to which individual sentences exhaust the acquired theme.

In attempting to further explore the distinction between a feature and schema model, Bransford & Franks (1973, p. 222 ff.) ran a variation on their basic paradigm. Two different lists of acquisition sentences composed of concatenations of the same set of underlying semantic propositions containing a single relation were presented to *S*s under two different conditions. The first list was 'unconstrained' and sentences expressed all possible combinations of ideas, whereas the second list was 'constrained' in the possible combination of ideas to be consistent with four themes which expressed the relation among four determined ideas each. The two lists were presented to different *S*s during an acquisition phase. During recognition, *S*s in both conditions received old sentences presented during acquisition and new sentences which, in the case of the unconstrained condition, consisted of random combinations of ideas, whereas the constrained condition consisted only of new combinations of sentences which were consistent with the four themes presumably acquired.

The authors argue that since both the unconstrained and the constrained lists were analyzable into the same basic set of features, that is, all acquisition sentences were concatenations of the same set of basic simple active declaratives containing one relation, the recognition memory results for both groups should be the same. First, since both old and new sentences are derivable from the same set of basic ideas, *S*s should not be able to distinguish among these. Second, under the feature model assumption mentioned above, recognition confidence ratings should covary with the number of semantic ideas (features) contained in the recognition sentence. Third, non-case sentences which were only presented to the constrained group for the obvious reason that non-case sentences were combinations of all possible ideas, should not be distinguishable since these have the same set of prepositions underlying the acquisition sentences.

However, the recognition confidence ratings for the two conditions, unconstrained and constrained, were very different (see Figure 3, 4, p. 153). The constrained condition results closely parallel the results from the previous studies, whereas the constrained condition results are markedly different. Subjects can discriminate old from new sentences and their recognition confidence ratings do not covary with the number of semantic ideas contained in the recognition sentence. These results then do not support the predictions made on the basis of a feature model and suggest that something more than a list of independent features has been stored.

A schema model which assumes the construction of wholistic semantic representations can account for these results. Since this model assumes that information about the relations among ideas is stored in addition to the ideas themselves, it might anticipate that the unconstrained acquisition list should be quite confusing. In contrast to the constrained list, where the relations among ideas are highly regular (in accordance with the *a priori* chosen themes), the unconstrained list consist of sentences expressing combinations among ideas which are random. That is, each sentence in the unconstrained list contains a unique combination of ideas. Hence, *S*s in this condition had considerably more information to acquire than *S*s in the constrained list who had only four themes (each composed of four ideas) to acquire. Subjects in the unconstrained condition should therefore be able to distinguish old from new sentences since the latter were indeed totally new combinations of ideas never before experienced. In effect, the new sentences for this group were similar to the non-case sentences for the constrained group. In the unconstrained condition *S*s were not able to abstract themes which might permit the recognition of novel sentences during recognition; rather, if they acquired anything, it was a long list of ideas. Therefore these *S*s should demonstrate considerable uncertainty in their recognition confidence ratings. In fact *S*s did not show the expected "linear effect". No matter how many propositions were contained in the recognition sentence confidence ratings were very low. These low confidence ratings may be attributed to confusion due to the sheer amount of information presented, and the ability to distinguish old from new sentences due to the fact that the latter were essentially non-case sentences with respect to the information acquired during acquisition. While this is admittedly a *post hoc* explanation, the results of the study are clearly inconsistent with the feature model presented above, but not necessarily inconsistent with the schema model.

Before we examine some of the attempts to replicate these results several restrictions of the schema phenomena should be noted. Thus

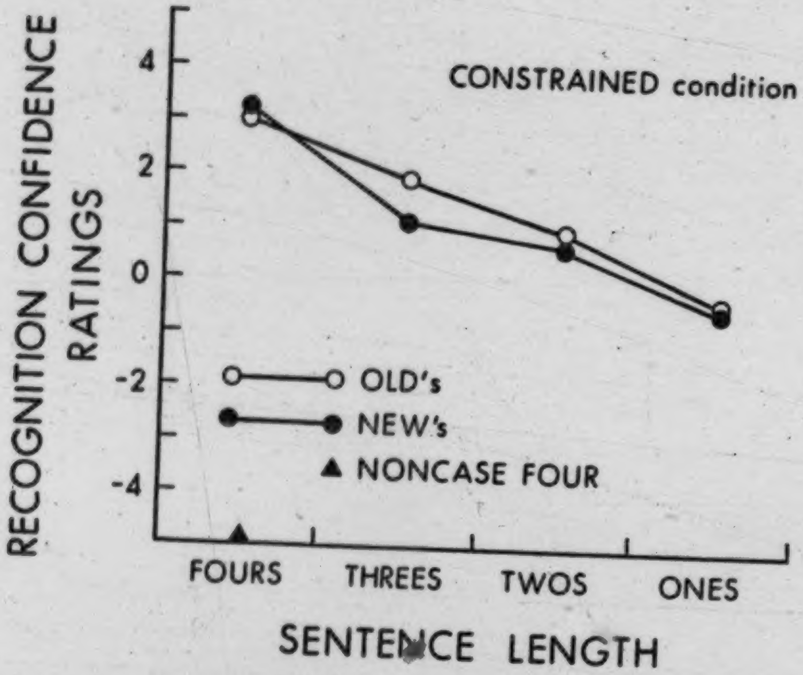


Figure 3. Recognition confidence ratings for old and new sentences of various lengths (from Bransford & Branks, 1973, p. 224).

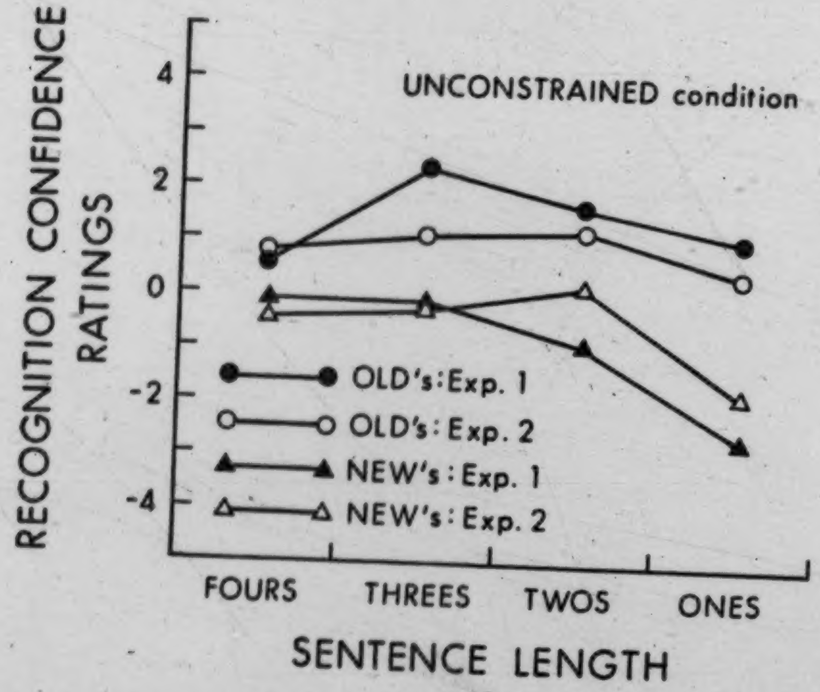


Figure 4. Recognition confidence ratings for old and new sentences of various lengths (from Bransford & Franks, 1973, p. 225).

Curnow (1969) varied the important acquisition instructions and found that *explicit* memory instructions prior to acquisition did not destroy the phenomenon. Thus, as an objection to the above results, it may be argued that the failure of *S*s to distinguish old from new sentences during recognition memory is in large part due to the non-instructions (to 'remember') prior to acquisition. However, Curnow found that when *S*s were explicitly told to remember acquisition sentences verbatim, only the slope of the recognition confidence ratings was less steep suggesting that *S*s were less uncertain about *both* old and new sentences during recognition. This finding is important for it points to the robustness of the rather vague notion of integration. It should be noted that while a recent study by Katz, Atkeson, & Lee (1973) included in the acquisition instructions something to the effect that the sentences to be presented were in some sense related, this was never the case in the Bransford & Franks research. That is, it was assumed *S*s would spontaneously integrate the material which was to be presented to them during acquisition.

Katz (1973) in another study on the effects of various instructions on the abstraction of ideas, found that the linear effect disappeared altogether when *S*s were instructed prior to recognition memory to indicate whether the sentences they were about to hear "meant exactly the same thing as the sentences they heard in acquisition". This is in contrast to the Bransford and Franks research where recognition memory instructions asked *S*s to indicate which of the "sentences in the new set they had actually heard before and which ones they had not" (Bransford & Franks, 1971). Katz expressed surprise at his finding since he considered his instructions more appropriate to the paradigm than the original Bransford & Franks instructions. However, this is not necessarily so, particularly as the request for 'meaning' may result in an excessive attempt to introspect on the part of the *S*, and thereby attempt to 'recapture' the original sentences resulting in uncertainty and considerable confusion. Subjects should be spontaneously engaged in the recognition memory task.

Another intuitively important parameter in this paradigm is the length of the sentences presented during acquisition. Thus if all the sentences presented in acquisition expressed a single relation (idea) one would not expect *S*s during recognition memory to actually think they had heard sentences expressing more than one relation (some concatenation of two, three or four ideas). Thus in addition to the construction of a wholistic semantic representation, subjects do remember something about the form of the input sentences from which the representation is abstracted. If the acquisition list was composed of sentences expressing only a single idea, this may be sufficient for the abstraction of a wholist semantic representation, but it would effectively prevent its detection in recognition memory as sheer sentence length would become a dominant feature. Hence, acquisition sentences must be varied to express single ideas and concatenations of two and three ideas (the concatenation of four ideas would constitute the theme and would not be presented in acquisition) so that sentence length constitutes a random variable that may be ignored. Curnow, in the study already cited, varied the length of the acquisition sentences and found the phenomenon of integration robust except under the extreme condition where only sentences expressing a single idea or a concatenation of two ideas were presented during acquisition (Curnow, 1969).

Sentence length during acquisition is crucially related to another parameter, namely, the length of the time interval between acquisition and recognition. Bransford & Franks and others have used a five minute interval and have consistently replicated their results (see for example, Katz, 1973; Reitman & Bower, 1973), yet this temporal parameter requires further study since specific memory for acquisition sentences must surely be related to this interval despite randomization of sentence length during acquisition. Thus it might be predicted that some optimal interval is minimally required to eliminate specific memory effects and that, when this interval is too short, memory would be specific to acquisition sentences or, if too long, recognition memory would constitute sheer guesswork.

Finally, the recognition memory procedure is employed in contrast, say, to recall memory, because the results should not depend upon memory for specific sentences but memory for ideas. Nevertheless, if recall were employed as the dependent measure we should expect an essentially similar pattern of results with an overall reduction in accuracy. In some pilot work Bransford & Franks report that 45% of new sentences, 55% of old sentences, and less than 5% of non-case sentences were accurately recalled (Bransford & Franks, 1973). Thus, these recall memory results confirm the previous findings that *S*s do not simply store individual sentences but integrate information from exemplars since it would otherwise be difficult to explain the recall of new sentences. That these results are not simply due to chance is indicated by the fact that *S*s recalled sentences expressing three and four ideas as readily as old sentences containing a single idea.

There have been several critical studies of the Bransford-Franks phenomenon. The first by Reitman & Bower (1973) was particularly critical of the claim that *S*s do not retain any specific exemplar information at all and only learn to retain an 'abstract principle' abstracted from experience with exemplars. The authors present three specific criticisms of the Bransford-Franks results. These are examined below with the supporting evidence.

First, Reitman & Bower maintain that the conclusion that *S*s learn and retain only an abstract principle (schema) and not particular exemplars is possibly the result of memory overload. That is, since *S*s are exposed during acquisition to a large number of exemplars from different themes, and since the exemplars belonging to any one particular theme have considerable overlap, we may anticipate both "massive forgetting" of, and interference among exemplars. Now it should be noted that this argument is hardly telling against the Bransford & Franks conclusions; it simply provides another explanation of why *S*s could not distinguish old from new exemplars. Instead of the claim that *S*s acquire a "general principle" Reitman and Bower claim the results are due to confusion and forgetting. In rejoining, it must be noted that if this is the case, and it may be argued that the experimental paradigm is so constructed that *some* confusion and forgetting (of form) is bound to occur, it is certainly a peculiar form of forgetting. For consider that under the instructions "to indicate which sentence they had actually heard before, " *S*s showed various degrees of confidence for both old and new sentences, rejected non-case sentences, and showed 'productivity' in the recognition memory for the sentence expressing the entire theme.

The latter brings us to the second criticism by Reitman & Bower namely that the Bransford & Franks research lacked a proper control group, one where *S*s would be exposed to a set of non-overlapping sentences constructed not in accord with any principle or rule but by randomly selecting and combining ideas from a small unordered set of ideas. This control group would constitute in effect a 'non-theme' condition. The authors argue that if *S*s within the control group also fail to distinguish old from new sentences it might then be argued that the failure of *S*s to distinguish old from new sentences in the Bransford & Franks paradigm is the result of information overload, interference and/or forgetting, and not the result of the abstraction of a schema or general principle.

In rejoining it should be noted that it was precisely because of these considerations that Bransford & Franks included non-case sentences in recognition memory. However, Reitman & Bower argue that non-case sentences would be rejected even in a control group where *S*s should be able to reject recognition sentences which deviate from those which they heard earlier in acquisition. Thus they claim that it is not enough simply to demonstrate recognition of case versus non-case sentences. What Bransford & Franks " ... failed to demonstrate ... [was] ... that their *S*s retained anything beyond the atomic propositions" (sentences expressing a single relation or idea). It is simply not convincing to demonstrate that *S*s can distinguish case from non-case sentences since the latter were never presented during acquisition whereas the former were presented alone or in combination with other ideas several times in acquisition as well as in recognition.

While this criticism appears to be more valid, namely the rejection of non-case sentences is insufficient as evidence for the acquisition of the theme, it should be noted that this was not the only basis for the conclusion that *S*s acquire a schema and do not simply retain a list of exemplars. Both the failure to distinguish old from new sentences and the "linear effect" supported this argument. It is only the former which Reitman & Bower have seriously questioned. In addition, the control group that Reitman & Bower recommend was employed in the constrained versus unconstrained study by Bransford and Franks cited above (Bransford & Franks, 1973). In that study it was found that *S*s in the unconstrained condition (which is comparable to the control group recommended by Reitman & Bower) did distinguish between old and new sentences, suggesting that *S*s' failure to do so in the constrained group was not due to interference or forgetting but due to the acquisition of the schema.

Reitman & Bower have attempted to replicate the Bransford & Franks results using instead of semantically meaningful material, letters and digits generated by the same rule. In addition to certain procedural changes, the authors also added two control groups, one in which there were no themes and one in which the themes were less than obvious. Thus there were three groups: the first two were different in terms of the obviousness of the themes to be acquired. The 'obvious' condition consisted of such concepts or themes as, 1, 2, 3, 4; A, B, C, D; w, x, y, z; the 'less obvious' condition involved such concepts as 4, 1, A, B; 3, y, z, D; and w, 2, C, z. For both these groups recognition memory lists included both "legal" and "illegal" strings. Hence the recognition lists contained old-legal, new-legal, new-illegal (order violation: 4, 1, 2, 3) and new-illegal (both order and set violation) strings. A third "random" condition contained a random combination of elements (letters and digits) in each string.

The results (Figure 2, p. 149) indicate that *S*s could easily distinguish old from new legal strings in all three conditions. Similarly, in both the "obvious" and "less obvious" conditions *S*s clearly rejected new illegal (both order and, order and set violations) strings which in fact were equivalent to non-case strings. The finding that *S*s can distinguish old from new legal strings is clearly in contradiction to the findings of Bransford & Franks, however, the rejection of illegal strings is quite consistent with the rejection of non-case sentences. Reitman & Bower also examined the function relating confidence ratings to the length of the string. In the 'obvious' theme condition, they found a positive linear relation between recognition confidence ratings and string length, however in the 'random' condition they found the inverse, namely a negative linear relation between confidence ratings and the length of the string. Finally, in the less obvious condition they found no relation between recognition confidence ratings and amount of information or length of the string. The authors speculate that the latter group represents some "mixture" of the first two groups.

The Reitman & Bower findings suggest that *S*s do have specific memory for those strings which were used as the basis for abstracting the general rule of schema. They conclude that both the semantic material and the procedure used in the Bransford & Franks studies are a hinderance to the retention of particular exemplars and that a more accurate characterization of their results would be that conceptual rules or schemas may be abstracted and retained despite conditions which hinder retention of information from particular exemplars. Since Reitman & Bower confirm the "linear effect" between recognition confidence ratings and the length of the string, the Bransford & Franks explanation in terms of the acquisition of a schema is acceptable to them. Now it should be noted that Bransford & Franks never denied that *S*s might be able to retain particular exemplars, but rather, that this is not the usual practise in listening or reading for understanding. Hence their paradigm was designed to eliminate specific memory effects which may be due to the demand characteristics of the experiment.

A second more disturbing finding in the Reitman & Bower study is that of the negative linear effect found in the random condition. Bransford & Franks have argued on the basis of their results in the 'unconstrained group', that the absence of a linear effect was due to confusion among the random sentences in the recognition list. However, this explanation will not do for the Reitman & Bower results. For while *S*s in the unconstrained condition were able to distinguish old from new sentences, the absolute size of this distinction was minimal, while in the Reitman & Bower study *S*s were clearly able to distinguish old from new sentences. Hence appeal to confusion as an explanation for the absence of the linear effect is unwarranted. However, if there was no confusion, how is it that Reitman & Bower find a negative linear relation between recognition confidences ratings and length of string in the random group since presumably no theme or concept could have been acquired by these *S*s?

Here Reitman & Bower resort to a feature analytic model and attempt to provide a probabilistic explanation. Thus, the set of training strings (in acquisition) generates a frequency distribution for features, and recognition ratings for test strings are computed from this distribution. For example, the *S* may be presented with the pattern

1, 2, 3, but 'tags' are attached to various features of this pattern: to individual elements 1, 2, and 3, to digrams 1-3, 3-4, and to the trigram 1-2-3. During recognition, the first check is for recognition and frequency of individual features, then for digrams, trigram and, if necessary, the entire theme. If any one individual feature is not recognized, the entire string is rejected. If the individual features are recognized, recognition for frequency of combinations of features becomes the crucial variable. Hence in the random condition, since individual features occur most frequently and combinations of features less frequently, there obtains the negative linear effect. This is in contrast to the 'obvious' condition where legal strings contain only legal features and hence the longer the string the higher the recognition confidence rating with the resulting positive linear effect. While this explanation is clearly predictive of the results, its validity is questionable as it requires of the *S* an internal computation which is rather detailed and lengthy (see Reitman & Bower, 1973).

A somewhat similar explanation is proposed for the Bransford & Franks results in a recent volume by Anderson & Bower (1973). These authors propose a human associative memory model (HAM) where each idea or proposition is stored individually tagged with an appropriate context. By context, the authors minimally refer to the location and time when the sentence was experienced (see Anderson & Bower, 1973, p. 139). It is important to note that HAM stores propositions and their contexts, hence if a sentence contains two propositions each will be stored as the context for the other and the number of contexts will increase for a particular sentence as the number of propositions in the sentence increases. Thus HAM will have no difficulty rejecting non-case sentences, as the intersection of propositions-in-context from these sentences will not be stored. Similarly, HAM also predicts, under the assumption that specific contexts may be interfered with and forgotten, that *S*s cannot distinguish old from new sentences in recognition memory. However, as the authors go on to point out, without this assumption HAM could indeed distinguish between old and new sentences. To accomplish this feat the *S* " ... must examine all the contextual linkages of all the propositions in the target sentence, determine if there are any intersections, check whether these intersecting contexts lead to all target propositions, and finally make sure that no non-target propositions are connected to any candidate contexts. Moreover, all these operations would have to be done with contextual tags that are virtually indiscriminable one from another" (Anderson & Bower, 1973, p. 350). The latter should be particularly so since, at least for sentences expressing a single proposition, the contextual tag is " ... little more than the fact that context was a particular moment in the experimental session" (Anderson & Bower, 1973, p. 350). Finally, the "linear effect" found in the Bransford and Franks results is predictable under the assumption that the *S* responds to the recognition sentence in terms of the number of context markers that are retrievable when recognition occurs.[3] Such a context counting strategy might similarly account for the failure to distinguish old from new sentences. Thus the average number of contexts evoked will be about the same for old, presented combinations of propositions as for new, non-presented combinations of propositions belonging to the theme. Therefore, if recognition memory occurs on the basis of the number of contexts retrievable from the recognition sentence, *S*s will be unable to distinguish old from new sentences which are consonant with the theme, moreover, recognition ratings should increase with the number of propositions in either new or old sentences.

Anderson & Bower clearly favour the context counting strategy over their complex computational explanation; however, they go on to state that this preference must be empirically decided. Thus they argue that the yes/no recognition procedure employed in the Bransford-Franks paradigm is not sufficiently sensitive to make such a decision, and the authors claim that a forced choice procedure would be more adequate to evaluate whether *S*s can distinguish old from new sentences.

Thus Anderson & Bower report a study where *S*s were presented with all recognition sentences at one time and asked to select which half they had heard before. Their findings are notably in contrast to the Bransford and Franks findings. First, *S*s were able to distinguish between old and new sentences; however, this must be qualified insofar as discrimination was high for both sentences expressing a single proposition and a combination two propositions, but *S*s failed to discriminate old from new sentences when these expressed a combination of three and four propositions. Second, the authors found no bias to give higher recognition confidence ratings to sentences with more than one proposition. Both these results can be accounted for by HAM under the assumption that recognition memory is probabilistic and occurs according to whether all propositions in the recognition sentence intersected at a unique context and not in terms of simply counting contexts. It may be assumed that the former strategy fails when the information load becomes too great and retrieval difficult, which may be the case for sentences expressing three and four propositions (Anderson & Bower, 1973, Ch. 11). The authors conclude that the forced choice procedure is more discriminating at least for sentences expressing one or two propositions.

Whereas Reitman & Bower (1973) questioned the finding that *S*s were unable to distinguish old from new recognition sentences on the basis that the experimental procedure inevitably resulted in memory overload and hence interference and forgetting, Katz, Atkeson, & Lee (1973) have questioned the linear effect and maintain that it is an artifact of the experimental paradigm. Thus, these authors claim that the presentation of redundant overlapping ideas in acquisition results in confusion in recognition memory as to whether the ideas presented are exactly in the same combination as those presented during acquisition. That is, the *S* may recognize the content of a sentence during recognition memory but be uncertain as to whether he heard it before in isolation or embedded in a sentence with other ideas. The authors report a study to decide the case.

Thus in addition to a control[1] condition which was similar to the one used by Bransford and Franks, an experimental[1] condition was presented during acquisition, with sentences containing only a single idea or proposition. The authors claim that " ... integration of ideas is possible in both conditions (although perhaps more difficult in the experimental condition) since even one-idea sentences contain semantic links to other sentences" (Katz, Atkeson, & Lee, 1973, p. 3). They go on to state that if the Bransford & Franks hypothesis is correct *S*s in both conditions should construct wholistic representations which may be used in recognition memory. That is, if Bransford & Franks are correct, recognition confidence ratings for sentences expressing a single proproposition should be similar for both the experimental and the control group. If however the linear effect is due to the method of stimulus presentation during acquisition, the recognition confidence ratings for one-idea sentences should differ in the two conditions. That is, in the control¹ condition, confidence rating should be similar to those reported by Bransford & Franks; however, in the experimental¹ group, since *S*s are " ... no longer required to decide whether a particular idea appeared alone or in combination with other ideas", and if we may assume they nevertheless acquired the complete theme, the ratings for single-idea sentences should be higher than for their counterparts in the control¹ group. In addition, the authors included two other conditions (control² and experimental²) which received non-case sentences, sentences expressing three ideas each and sentences expressing the entire theme. It should be clear that these two additional conditions are required to demonstrate acquisition of the themes. Non-case sentences could not have been included among the single-idea recognition sentences of the experimental¹ group since the latter would be clearly distinguished in form from sentences expressing three ideas.

Before examining the results, several comments must be made with respect to both the criticisms and the procedures employed by Katz, Atkeson, & Lee. First, if indeed the "linear effect" is an artifact of the method, it is difficult to understand why the effect is so orderly and reliable in a number of studies using different stimulus material (Bransford & Franks, 1972; Franks & Bransford, 1971; Katz, 1973; Reitman & Bower, 1973). Furthermore, if the results are due to confusion because of the various sentence lengths in acquisition, why should the theme receive the highest recognition confidence rating, particularly since it was never presented during acquisition? It is unlikely that confusion will result in high recognition confidence ratings for sentences never heard before.

Second, the proposed change in method for the experimental[1] group using exclusively single-idea sentences during acquisition seems inadequate largely because these may be combined in many ways (that is, these are largely unconstrained in Bransford & Franks, 1973), precluding the abstraction of the themes. Indeed Katz, Atkeson, & Lee recognized that if *S*s were unable to construct wholistic semantic representations from the acquisition sentences, then recognition memory would indeed be highest for single-idea sentences since it is only these which are presented in acquisition. It is doubtful whether the two additional conditions (experimental[2] and control[2]), which were included to evaluate theme construction by presenting non-case sentences in recognition, constitute a proper test of theme acquisition. Indeed as Reitman & Bower have claimed, non-case rejection does not provide convincing evidence that what is acquired is a particular combination of ideas (theme) or a relational structure typified by a rule.

Third, since single-idea sentences are exclusively presented in acquisition it is almost trivial to suggest that when these are again presented in recognition they should receive higher recognition confidence ratings than single-idea sentences presented in the control[1] experimental condition. That is, if single-idea sentences are recognized at all, it will be with certainty. It should be noted that this argument cannot be made against the control[1] condition, that is, one cannot argue that since *S*s were presented with acquisition sentences expressing one, two and three ideas, therefore if the sentence is recognized at all it will receive a low confidence recognition rating due to uncertainty about whether it was heard in precisely this combination. This is simply not the case for as we have seen recognition confidence ratings reflect the degree to which the sentence exhausts the meaning of the acquired theme (Bransford & Franks, 1971; Reitman & Bower, 1973).

Finally, the manner in which Katz, Atkeson, & Lee tested for the acquisition of the theme was to present 4 case and 4 non-case sentences and to ask *S*s whether these were consistent with the sentences heard in acquisition. This would appear to be a relatively simple task for *S*s who were presented with only 24 sentences in acquisition.

The results reported by Katz, Atkeson & Lee (1973) are as follows. The control^{1}condition results were similar to Bransford-Franks findings. Thus, both the linear effect and, in contrast to the Reitman & Bower findings, the inability of *S*s to distinguish between old and new sentences was clearly evident. The single-idea sentences in the control^1 condition received average recognition ratings of -.67 while the single-idea sentences in the experimental^1 condition received confidence ratings of 3.31 which was significantly higher. Since the two other groups, which were intended to evaluate the integration of ideas, rejected non-case sentences, the authors conclude therefore that " ... the null hypothesis that recognition confidence ratings for experimental *S*s do not differ from those for control^1 *S*s cannot be rejected" (Katz, Atkeson & Lee, 1973, p. 9). This is to say that both experimental^2 and control^2 *S*s rejected non-case sentences equally, but says little about whether the two groups experimental^1 and control^1, acquired themes.

However, if we grant the assumption that both conditions indeed acquired themes, the difference between recognition confidence ratings for single-idea sentences in the two conditions is taken as evidence that the "linear effect" in the control^1 condition is an artifact due to confusion during acquisition. However, as was previously pointed out, not only does the composition of the experimental^1 group raise a number of problems, but it may be argued that since the control^1 group contained both new and old sentences (of various length), the former might have acted as "distractors" and reduced overall recognition confidence ratings including those for single-idea sentences. Katz, Atkeson & Lee argue that this obtains only if *S*s can distinguish old from new sentences and since this is not the case new sentences are not distractors. However, rather than focus on the low recognition confidence ratings in the experimental^1 group, it may be argued that instead the focus should be on the relatively low recognition confidence ratings, given the experimental procedure, in the experimental^1 group. Thus why should *S*s not give the maximum confidence rating to single-idea recognition sentences since these were the only ones they heard in acquisition? Probably for no other reason than the 'decay' of the list of single idea sentences.

Interestingly enough, Katz, Atkeson & Lee do attempt to provide an explanation for the "linear effect" found by Bransford & Franks. The authors put forward the hypothesis that *S*s assign recognition confidence ratings based on the probability that a sentence expressing a particular number of ideas could have occured in acquisition. They do this by estimating the total possible number (set size) of sentences of varying complexity (number of idea combinations), and then formulating a probability on the inverse of that set size. Hence, since the maximum set size is greatest for sentences expressing one idea and least for sentences expressing four ideas, the probability estimates, and hence confidence ratings, would yield a reverse ordering. This explanation can also handle the results from the "random" condition in the Reitman & Bower study. Thus in the "random" condition where all possible permutations and combinations of elements (letters and numbers) is permissible, the set size of strings of four elements becomes the largest and the set size of strings of one element the smallest and hence recognition ratings for single element strings should be higher than for four element strings. This negative linear effect was precisely the result (Figure 2, p. 149). Furthermore, this explanation might also handle the Bransford & Franks (1973) findings. Their results for the unconstrained condition did not match the negative linear slope for the random condition in the Reitman & Bower study presumably because their *S*s were not exposed to all possible combinations (and no permutations) of ideas which would reduce the set size of higher complexity sentences compared to these same complexity strings in the Bower and Reitman study, and hence reduce the slope of the linear effect to almost zero, as indeed occured (Figure 4, p. 153).

This statistical method of identifying sentences is similar in kind to the context-counting strategy suggested by Anderson & Bower, (1973). Katz, Atkeson, & Lee put forward the same reason as these authors do why *S*s use it instead of explicit identification (judgement) of recognition sentences. That is, the nature of the acquisition task is such as to result in memory overload and inevitable confusion. However, since there is no such overload when single-idea acquisition sentences are employed, *S*s need not resort to a probabilistic strategy and can make explicit identification judgements. Hence one does not find the "linear effect".

Two comments are in order here. First, there is a more parsimonious explanation for the high confidence ratings of single-idea sentences (Katz, Atkeson, & Lee, 1973), namely pattern matching for a list of sentences which shows some decay due to the interval between acquisition and recognition. Second, the statistical explanation, at least as this is put forward by Anderson & Bower (1973) which divides the experienced linguistic event into context and fact, has many of the features of a schema or relational structure and hence might well provide another possible explanation for the Bransford and Franks results. In any case the various studies reviewed here (Reitman & Bower, 1973; Anderson & Bower, 1973; Katz, Atkeson, & Lee, 1973) all agree that the Bransford & Franks results suggest that *S*s disgard surface structure, integrate individual ideas into complex ones, and then rate new exemplars in terms of how many ideas these reinstate from the acquired theme.

CHAPTER 8

FOUR EXPERIMENTAL STUDIES OF THE ACQUISITION OF MEANING

The studies reported below were designed to demonstrate that what is learned and retained is always in the nature of concepts, abstract conceptual structures, which are acquired by a process of abstraction and elaboration of information from temporally disparate experiences. The abstract structure is not something psychologically substantive, as are words or images, but rather is an entirely functional code neutral with respect to the various perceptual modes and structures. That is, these studies were intended to demonstrate that non-sequential, consecutively presented, well structured information, either linguistically coded or graphically illustrated, in either the visual or auditory mode will be wholistically integrated, and that subsequent recognition of related information, in either perceptual mode and code, provides evidence that integration is both inferential and constructive. It is inferential in that the concepts acquired are unlike an enumeration of any of the exemplars from which these were abstracted, and it is constructive in that the concepts are abstracted from exemplars which are neither temporally nor spatially presented in any meaningful arrangement.

The four studies described below attempt to replicate and extend the various findings reported above (Bransford & Franks, 1971, 1973; Katz, 1973; Reitman & Bower, 1973). The first study was a straightforward replication of the Bransford & Franks experiment (Bransford & Franks, 1971, Experiment 3). However, in contrast to their study which was conducted entirely in the aural mode, the present study was conducted once in the aural and once in the visual mode. The second study was an attempt to replicate the preliminary findings reported by Bransford & Franks (1973) and Katz (1973) using sentences with "abstract" lexical items (Begg & Paivio, 1969). The third study attempted to replicate these findings using either graphically illustrated or sentential material in acquisition and sentential and graphically illustrated material respectively, in recognition. The fourth study, using bilingual *S*s, attempted to replicate the findings in the first three studies using sentential material in two different languages. Thus acquisition sentences in either English or Dutch were followed by recognition sentences in Dutch and English respectively.

The four studies were similar in procedure. Each study was designed to convey four different themes to every subject participating in the study. Each theme could be exhaustively characterized by those semantic relations contained in a single compound sentence (for example, The old man resting on the couch is reading the story in the newspaper). During an acquisition phase of the experiment, *S*s were never presented with sentences expressing the complete theme, but only with sentences expressing various subsets of semantic relations from each theme (for example, The man is reading the story; The old man is resting on the couch; The story is in the newspaper). Theme acquisition would be demonstrated if the acquisition procedure resulted in *S*s acquiring the complete theme by the integration of information contained in related sentences.

The experiments were designed to demonstrate theme acquisition and retention in as strong a manner as possible. Thus each experiment sought to demonstrate not only that *S*s could acquire the complete theme from experience with sentences expressing partial relations belonging to the theme, but also that the acquisition of the complete theme is so compelling that *S*s would actually think they had previously seen/heard sentences expressing the complete theme when in fact they had not.

To test for theme acquisition, a recognition test was administered sometime following the acquisition procedure. *S*s were told they would read/hear a series of sentences all of which were related to those seen/heard during acquisition. Their task was to decide which exact sentences they had seen/heard during acquisition, which ones they had not seen/heard, and how confident they were about their answers. Recognition sentences included sentences actually seen/heard during acquisition (OLD sentences), sentences not seen/heard during acquisition but which were consonant with the ideas expressed there (NEW sentences), and sentences neither seen/heard during acquisition nor consonant with the ideas presumably acquired (NON-CASE sentences).

To the extent that *S*s do acquire themes during acquisition the following results were expected: First, *S*s should show evidence of productivity. That is, they should think they recognize novel sentences (NEW) which are consonant with the acquired theme in spite of the fact that they had not seen/heard these before. Some of these novel sentences contain semantic relations or combinations of ideas never expressed by a single sentence presented during acquisition. It is these new sentences which are of particular significance as their recognition could not be accounted for by memory of any previously experienced sentence. Conversely, it is important to see whether *S*s can partition the set of acquisition sentences from those novel sentences presented during recognition.

Second, assuming that *S*s will actually acquire complete themes on the basis of experience with sentences presented during acquisition, some additional results might be expected with respect to *S*s' confidence ratings for having seen/heard certain sentences. These ratings may be expected to reflect the degree to which any recognition sentence represents or reinstates what was learned in acquisition. If *S*s indeed acquired themes, those sentences expressing the complete theme should receive the highest recognition confidence ratings. Consistently, such ratings should reflect the extent to which any recognition sentence exhausts the meaningful relations characteristic of the complete theme. Similarly it follows that *S*s should be very confident that they had not seen/heard the NON-CASE sentences for while these are similar in both syntactic structure and lexical content to both OLD and NEW sentences, their semantic relations are very different from those expressed in any one theme.

Third, in order to rule out contiguity of sentences in acquisition as a possible explanation for the results an additional control was incorporated in the acquisition procedure. Sentences related to each of the four themes were randomly presented during acquisition, with the restraint that no sentences related to the same theme occur consecutively on the acquisition list. Therefore acquisition of complete themes must occur by integrating information from successive but non-consecutive instances of the four themes. Since the acquisition list was presented as a short-term memory task and *S*s were not told about the recognition test, integration of information was expected to occur spontaneously.

In summary, the expected findings for all four studies were identical. First, under the assumption that *S*s acquire themes on the basis of experience with exemplars, they should demonstrate evidence of productivity. That is, *S*s should not be able to distinguish new from old recognition ideas so long as both are consonant with the theme acquired. Second, under the assumption that recognition confidence ratings reflect the acquisition of the theme, *S*s' confidence ratings should increase as a function of the degree to which old and new ideas exhaust the semantic content of themes ("linear effect"). Third, both new and old ideas should be clearly distinguishable from ideas which are not related to the acquired theme.

However, it became evident in some preliminary research that certain of the procedures employed were crucial with respect to the results. First, it was found, in contrast to the Bransford and Franks findings, which were obtained using a five minute delay between acquisition and recognition, that these results could not be replicated unless the delay was considerably increased. That is, with only a five minute delay and no intervening task demands (Bransford & Franks, 1971), *S*s were able to partition the old from new sentences in the recognition list with considerable accuracy. On the other hand, the fifteen minute interval was chosen on the basis of some pilot work which replicated the results reported by Bransford and Franks.

Second, preliminary research also showed that a considerable number of *S*s would not use the entire range of the five point confidence rating scale. That is, a particular *S* would proceed to mark all 5's ("very sure"), mostly 3's, or else all 1's ("not sure"). To prevent this from occurring, the instructions emphasized that *S*s should take their time in marking their confidence ratings and they were encouraged to make use of the entire confidence range. In fact, *S*s who did not make use of the entire confidence range during the first ten responses (Page 1 of the recognition booklet) in spite of the instructions were eliminated from these studies. (This procedure eliminated about 25 out of 185 *S*s who participated in the first three studies.) All *S*s in the fourth study made use of the entire confidence range.

At the completion of each experimental session, the *E* questioned the *S* particularly with respect to his understanding of the material. For example, several *S*s indicated that at first they did not grasp the meaning of a word but would later understand it in another context (Experiment 2). These *S*s were eliminated from the experiment. To avoid such difficulties only *S*s who were native speakers of English, excepting those *S*s who participated in the Experiment 4, were included in this research.

Similarly, all *S*s who attempted in their recognition and confidence ratings to be consistent with their previous responses (and this was easily detected and contrary to the instructions which included the specification that *S*s respond intuitively without trying to be consistent with themselves) were also eliminated from the experiment. This does not preclude the inclusion of other *S*s who were trying to be consistent in their responses, just those whose latency to respond was in the order of several minutes were eliminated from the study.

In fact without these selection restrictions, the phenomenon of productivity, that is, recognition of novel material, could not be obtained in preliminary research. It is indeed surprising that the results obtained by others (Anderson & Bower, 1973; Bransford & Franks, 1971, 1973; Katz, 1973; Reitman & Bower, 1973) were so clear cut, given that these studies employed relatively few *S*s and without any apparent selection restrictions. The pilot work done for the present set of experiments indicated very clearly that without the above restrictions, these earlier results could not be replicated. Nevertheless, it may well be that the *S*s in these other studies were more carefully chosen than what was reported. The phenomenon is there, but not by randomly accepting all *S*s, or by using an acquisition-recognition interval of only five minutes. These considerations will be further discussed in the individual studies reported below.

Experiment 1.

This experiment was essentially a replication of the third study reported by Bransford & Franks (1971). However several significant changes were incorporated in the present study, the details of which are outlined in the *Procedure* below. In summary, these changes were as follows: the experiment was conducted in both the aural and the visual mode; the temporal delay between the acquisition and recognition phase of the experiment was extended from five to fifteen minutes; the experiment was administered individually to every *S*; and there were several minor changes relating to number of *S*s and format of the procedure which were meant to increase uniformity and hence reduce error variance.

Subjects. The subjects were 80 University of Alberta students enrolled in various Psychology courses during the summer, 1973. There were 37 males and 43 females *S*s ranging in age from 18-35 with a mean age of 26 years.

Materials. Materials consisted of a set of English sentences obtained from Bransford & Franks (1971, Study 3). These four compound sentences (themes) were each constructed to represent relations among four simple declarative sentences (ideas). Both the simple declaratives and the compound sentences were chosen intuitively without regard to their status in current linguistic theory. However, the sentences were fairly uniform in length and their lexical content was judged to be of equal difficulty. Each of the compound sentences (themes) was broken down into its four simple declaratives. These in turn were recombined in accord with following rule $S \rightarrow (A)(B)(C)(D)$, to yield a total of 12 sentences including the theme sentence. Therefore the complete complement of sentences derived from each theme consisted of the following: (1) A compound sentence consisting of four ideas (theme); (2) Four simple sentences each consisting of one idea; (3) Four sentences each consisting of two ideas; (4) Three sentences each consisting of three ideas. The complete set of sentences defining one particular theme is provided in Appendix A.

Recognition and confidence ratings were recorded for each recognition sentence in the experiment. The *S* indicated recognition by writing "Yes" or "No", and confidence rating by circling the appropriate number on a five point rating scale provided immediately following the recognition answer. The five point scale was labelled from 1 "not sure" to 5 "very sure".

Thus each theme was represented by one sentence expressing four ideas (FOUR), three sentences expressing three ideas (THREE), four sentences expressing two ideas (TWO), and four sentences expressing one idea (ONE). It should be noted that these are not all the possible sentences that could be constructed by application of the rule. By this rule there are $2^4-1 = 15$ possible sentences whereas only 12 were included above. The additional constraints which guided the deletion of three sentences were the simple dual considerations that relations among the nominal constituents remain in the same order as these were in the theme and that no combination of ideas that relied on knowledge other than provided in the theme be included. This eliminated three sentences each of which expressed two ideas.

All 48 sentences (12 sentences for 4 themes) were typed on 5 in. x 8 in. index cards. In addition 6 NON-CASE sentences were included. All NON-CASE sentences were constructed by combining 4 ideas across themes thereby violating the relationships expressed within themes. These are presented in Appendix B.

Other material consisted of a set of cards containing four different colour squares. These were used as an intervening colour-naming task between presentation of the sentence and an elliptical question about it during the acquisition phase of the experiment.

Procedure. All *S*s were presented with the experimental task individually. This procedure, which was decided upon in some pilot work were results showed that there are individual differences in performance, permitted *S*s to pace themselves. However, care was taken so that *S*s would not have the opportunity to rehearse the material. Each experimental session consisted of an acquisition and a recognition phase.

Acquisition. The task was presented as a short term memory task. The *S* was told that his task would be to answer a question about each sentence which was to be presented by the *E*. The procedure was a follows: (1) The *E* read or required the *S* to visually read a sentence; (2) The *S* was asked to name four colours in the order they appeared on an index card; (3) The *E* asked an elliptical question about the sentence just presented; (4) The *S* wrote down the answer to the question. This procedure was followed for each sentence on the acquisition list. The intervening colour naming task ensured that *S* would hold each sentence in memory for a period of about 5 - 7 seconds. The elliptical question was chosen so that each constituent of each phrase was questioned as often as every other constituents (for example, *The rock rolled down the mountain*, the elliptical questions were "Did what?", "What did?", "Where?").

Two sets of acquisition sentences were constructed. Each set contained 24 sentences, 6 related to each of the four themes. There was no overlap between the two acquisition sets in terms of the exact sentences used. Table 1 shows the number of each type of sentence (expressing ONE, TWO, THREE or FOUR ideas) used to construct each acquisition list.

Table 1.

Composition of the two acquisition lists for Experiments 1, 2 and 4.

	Themes							
	Theme 1		Theme 2		Theme 3		Theme 4	
Ideas	Acq. 1	Acq. 2	Acq. 1	Acq. 2	Acq. 1	Acq. 2	Acq. 1	Acq. 2
FOURS	1	0	0	1	1	0	0	1
THREES	1	2	2	1	1	2	2	1
TWOS	2	2	2	2	2	2	2	2
ONES	2	2	2	2	2	2	2	2

In this first study the composition of each list was such that it contained two sentences which expressed the entire theme. The order of presentation of the 24 acquisition sentences was arranged so that each successive sequence of four sentences contained one sentence from each of the four themes. Sentences were arbitrarily selected within each block of four with the restraint that no two sentences belonging to the same theme occur consecutively on the list. The ONES, TWOS, THREES, AND FOURS (from two themes) were randomly distributed across each acquisition list. The arrangement of sentences in the two acquisition lists is presented in Appendix C. Subjects were presented with the acquisition list only once, and were not told of the recognition phase of the experiment.

Recognition. Following a fifteen minute break during which *S*s were instructed to read a standard passage from an introductory Psychology textbook, the recognition phase was started. The instructions with respect to the intervening task implied that understanding the passage was important with respect to some later task. Following the break, the recognition task was introduced as follows: The *S* was told by the *E* that he (the *E*) was going to read or required the *S* to read (visual condition) a new set of sentences which were closely related to the set of sentences which the *S* had seen/heard during the acquisition phase. Their task was to indicate which of the sentences in the new set were exactly like those sentences seen/heard before and which ones were not. In addition to this recognition decision, the *S* was asked to indicate his degree of confidence with respect to this decision.

The recognition list consisted of 48 sentences, 12 belonging to each of the four themes. Twenty-four of these sentences would be OLD sentences presented during acquisition and twenty-four would be NEW sentences not seen/heard before. Thus *S*s who received acquisition list

1, received both this list (OLD sentences) and acquisition list 2 (NEW sentences). Similarly, *S*s who received acquisition list 2, received both this list (OLD sentences) and acquisition list 1 (NEW sentences). This arrangement permitted the comparison of confidence ratings for individual sentences for when it was old and when it was new. In addition to these 48 sentences, 6 NON-CASE sentences were randomly included in the list of 48. The 48 sentences were arbitrarily arranged with the constraint that no two sentences belonging to one theme occur consecutively. Recognition sentences, which included the NON-CASE sentences, were presented in one of two orders, 1 - 54, 54 - 1. Subjects who received the acquisition list aurally also received the recognition list aurally and *S*s that received the acquisition list visually also received the recognition list visually. That is, the entire experiment was completed in the same mode.

Design. The *S*s were arbitrarily assigned to 8 experimental conditions varying Mode of Presentation (A, aural or visual), Acquisition List (B, acquisition list 1, 2), and Recognition Order (C, recognition order 1, 2) orthogonally. During recognition each *S* rated all sentences from each of the four Themes (E). One-half of these recognition sentences belonging to each theme were from acquisition list "old", whereas the remaining sentences had never been presented in acquisition and hence were "new" sentences (O, Old/New Sentences). In addition, the length of both old and new sentences was varied containing from 1 - 4 ideas (L, Sentence Length), and several instances ("replications") of each sentence length were tested for recognition. The last factor, which was not completely crossed with Sentence Length (see Table 1), was treated as a dummy variable. Thus the experimental design may be characterized as a 2 x 2 x 2 x 4 x 2 x 4 x (2) factorial design with repeated measures over the last four factors.

Analysis. The initial analysis was performed on a 2 x 2 x 2 x 4 x 2 factorial design collapsing confidence ratings across Sentence Length and "replications", to assess the effect of Themes upon the recognition of Old/New Sentences. It was anticipated that in the absence of Theme main effect and interactions this factor could be eliminated from the subsequent analysis. Recognition Order (C) was considered a random factor.

The subsequent analysis consisted of a 2 x 2 x 2 x 2 x 4 factorial design collapsing confidence ratings across Themes and "replications" to assess the effect of Sentence Length upon recognition of Old/New Sentences. In the first analysis each data point consisted of mean confidence ratings across Sentence Length and "replications", and in the second analysis across Themes and "replications". The two separate analyses were required because Sentence Length was not completely crossed with Themes (see Table 1).

Results. Tabulation of recognition confidence ratings showed that of the 3840 (80 *S*s x 48 sentences, excluding non-case sentences) responses only 13.0% were negative recognition confidence ratings and these were restricted to new sentences expressing a single idea (ONES) in the visual mode of presentation and both old and new ONES in the visual mode of presentation and both old and new ONES in the aural mode of presentation.

Since neither the main effect nor interactions with Theme were statistically significant, a factorial analysis of variance for Sentence Length, collapsed over Themes, was justified. These results are presented in Table 2. The 3-way Mode of Presentation x Old/New Sentences x Sentence Length (AOL), significant interaction which summarized the various other significant effects (A, O, L, AO, AL, OL), is presented in Figure 5. In addition, the Mode of Presentation x Sentence Length (AL) significant interaction is presented in Figure 6.

It was evident from Figure 5 that the significant effects due to [illegible] of Presentation (A) and Old/New Sentences (O) were the result of differential recognition confidence ratings for sentences expressing a single idea (ONES). Regardless of acquisition list, old ONES received higher recognition confidence ratings than new ONES in both the aural and visual mode of presentation. Old ONES received positive recognition confidence ratings, whereas new ONES received negative recognition confidence ratings and this effect was greater in the visual than in the aural mode of presentation. Therefore, *S*s were able to distinguish ONES presented in acquisition from those which they had not seen before.

However, regardless of acquisition list sentences, *S*s were unable to distinguish old from new sentences when these expressed two, three, or four ideas. That is, *S*s' ability to distinguish old from new sentences was specific to sentences expressing a single idea. If *S*s remembered precisely those sentences which were presented in acquisition, these same sentences in recognition (old sentences) should have received higher recognition confidence ratings than new sentences. This was clearly not the case. Furthermore, all four theme sentences (FOURS) of which only two were presented in any acquisition list and all 12 THREES of which only 8 were presented in any acquisition list (see Table 1), received similar recognition confidence ratings dependent, of course, on sentence length. That is, 2 FOURS and 4 THREES which contained

Table 2.

Experiment 1 results of the Analysis of Variance for Mode of Presentation (A) x Acquisition List (B) x Recognition Order (C) x Subjects (S(ABC)) x Old/New Sentences (O) x Sentence Length (L) factorial design.

Source of Variance	Mean Square	Error Term	d.f.	F
A Mode	18.5943	AC	1	5165.08**
B List	0.0530	BC	1	0.57
C Order	0.0001	S(ABC)	1	0.01
O Old/New	188.8667	CO	1	1162.86**
L Length	562.7119	CL	3	8974.67**
AB	0.1619	ABC	1	1.54
AC	0.0036	S(ABC)	1	0.01
BC	0.0917	S(ABC)	1	0.33
AO	64.0706	ACO	1	317.81**
BO	.1285	BCO	1	1.63
CO	.1625	SO(ABC)	1	0.09
AL	15.1534	ACL	3	484.10**
BL	0.7380	BCL	3	8.15
CL	0.0627	SL(ABC)	3	0.27
OL	141.6134	COL	3	1895.70**
ABC	0.1041	S(ABC)	1	0.38
ABO	0.1696	ABCO	1	18.52
ACO	0.2016	SO(ABC)	1	1.23
BCO	0.0785	SO(ABC)	1	0.48
ABL	0.0414	ABCL	3	0.95
ACL	0.0313	SL(ABC)	3	0.13
BCL	0.0726	SL(ABC)	3	0.32
AOL	76.8266	ACOL	3	1383.01**
BOL	0.0812	BCOL	3	3.23
COL	0.0747	SOL(ABC)	3	0.35
S(ABC) Subjects	0.2733		72	
ABCO	0.0092	SO(ABC)	1	0.05
ABCL	0.0432	SL(ABC)	3	0.19
ABOL	0.0644	ABCOL	3	4.18
ACOL	0.0555	SOL(ABC)	3	0.26
BCOL	0.0251	SOL(ABC)	3	0.11
SO(ABC)	0.1629		72	
SL(ABC)	0.2249		216	
ABCOL	0.0154	SOL(ABC)	3	0.07
SOL(ABC)	0.2919		216	

$^{**}p<0.01$ $^{*}p<0.05$

Figure 5. Recognition confidence ratings for the Mode of Presentation x Old/New Sentences x Sentence Length interaction in Experiment 1.

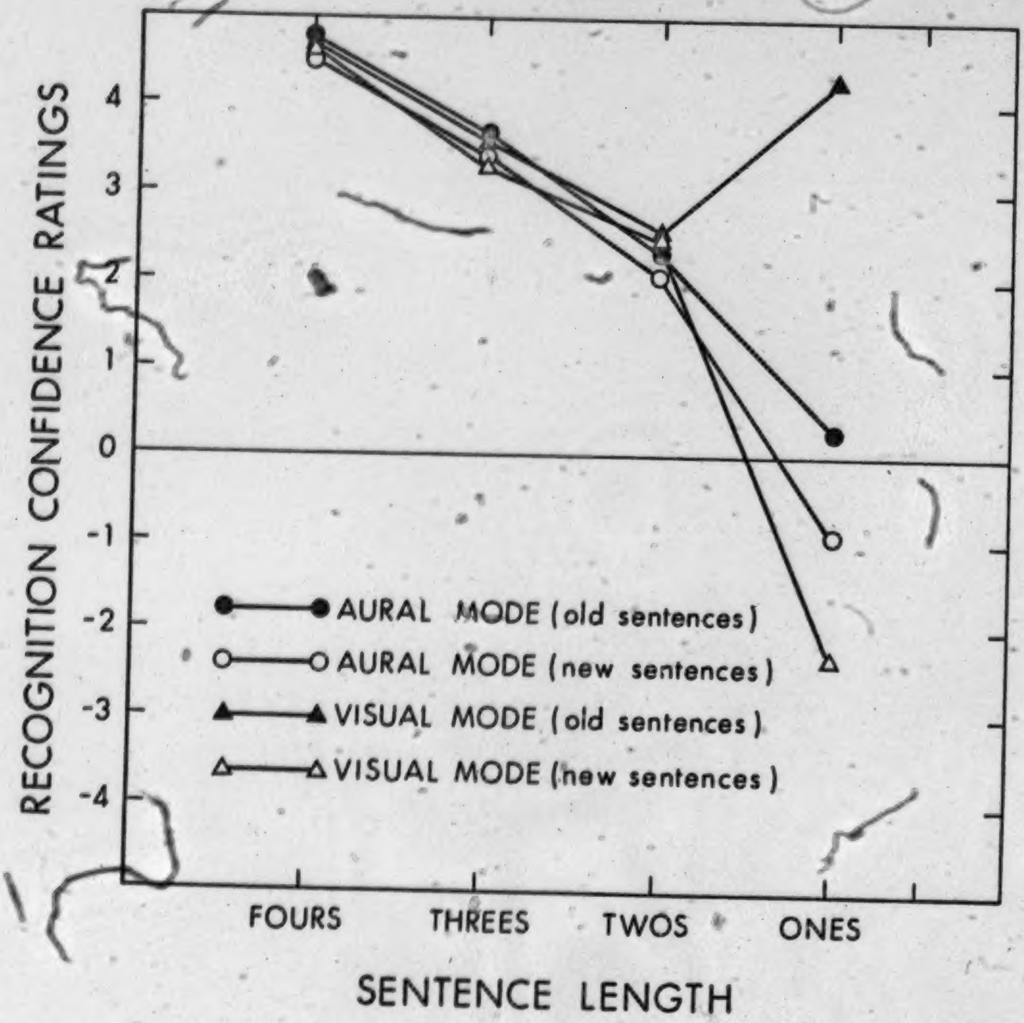
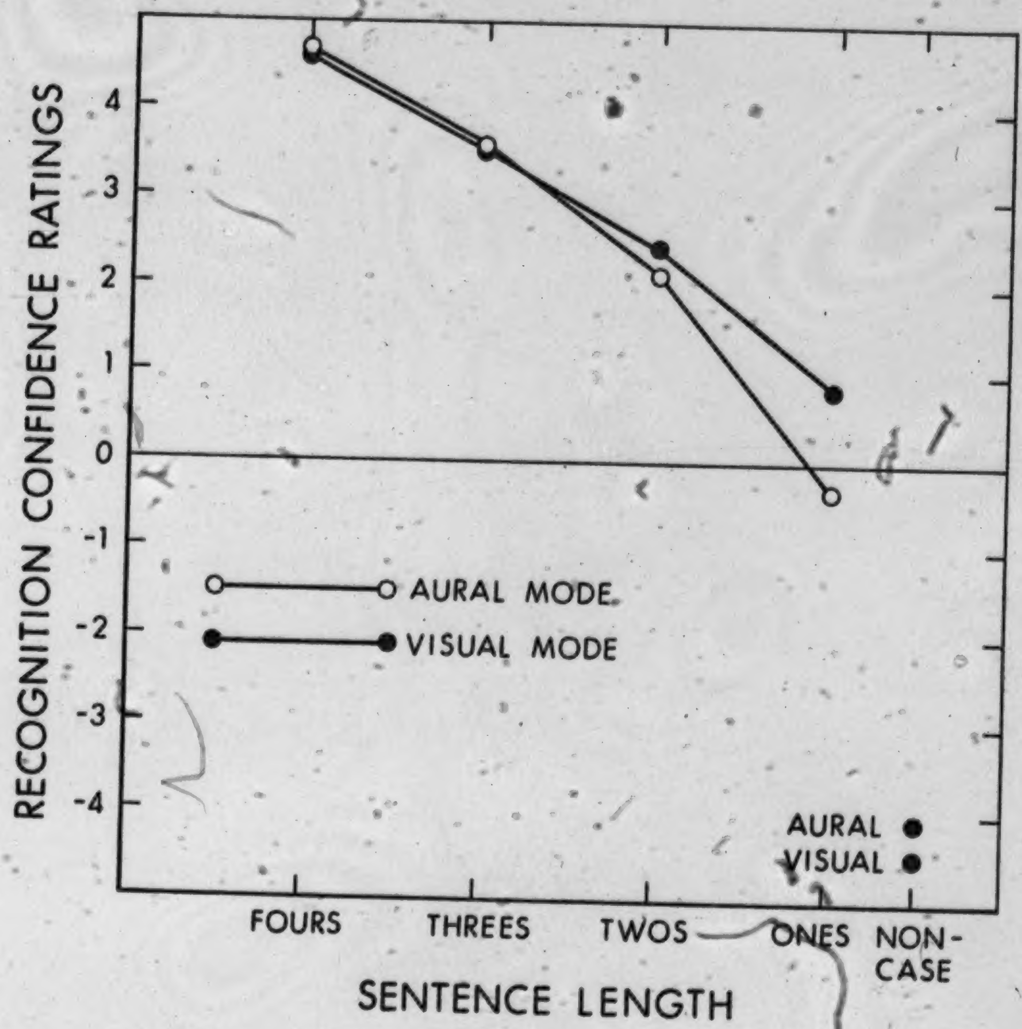


Figure 6. Recognition confidence ratings for the Mode of Presentation x Sentence Length interaction in Experiment 1.



combinations of relations which *S*s had never before experienced in any single acquisition sentence, regardless of acquisition list, were not distinguished from other old and new THREES and FOURS.

The significant effects due to Sentence Length (L) were the result of the finding that recognition confidence ratings were ordered: FOURS> THREES>TWOS>ONES (Figure 6). That is, recognition confidence ratings were a function of the number of and hence, extent to which, ideas and relations exhausted the semantic content expressed in theme sentences. This "linear effect" was similar in both the aural and visual mode of presentation with the exception of those sentences which expressed a single idea. As is evident from Figure 6, *S*s in the visual mode of presentation gave positive recognition confidence ratings to ONES, however, this finding was primarily the result of high positive recognition confidence ratings to old ONES in comparison to intermediate negative confidence ratings for *new* ONES (Figure 5). Similarly, while *S*s in the aural mode of presentation gave negative recognition confidence ratings to ONES (Figure 6), this finding was due to the relatively higher negative confidence ratings for new ONES in comparison to the lower positive confidence ratings for old ONES (Figure 5). These findings for ONES reflected the Mode of Presentation x Old/New Sentences x Sentence Length (AOL) significant interaction. In conclusion *S*s were able to distinguish old from new ONES, the former received positive recognition confidence ratings, and the latter negative recognition confidence ratings in both the aural and visual mode of presentation. One qualification to this conclusion pertained to the visual mode of presentation where the positive confidence ratings for old sentences and the negative ratings for new sentences appeared rather more extreme than in the aural mode of presentation.

All *S*s rejected non-case sentences which were not consonant with any of the relations expressed by acquisition sentences (see Figure 6). That is, all *S*s gave high negative recognition confidence ratings to non-case sentences.

In summary, *S*s were unable to partition the set of old from new sentences with the exception of ONES, in which case old sentences received positive confidence ratings and new sentences received negative confidence ratings. These findings were more marked in the visual than the aural mode of presentation. *S*s' recognition confidence ratings were ordered as a function of the number of ideas per sentence. Sentences which expressed the entire theme received the highest recognition confidence ratings even when these had never before been presented to the *S*. Finally, all sentences which were not consonant with the ideas presented or acquired in acquisition were clearly recognized as novel sentences.

Experiment 2

The second experiment, with two exceptions, was formally identical with Experiment 1. The two exceptions were as follows: First, the experiment was conducted only in the aural mode. The aural mode was chosen in view of the findings in Experiment 1 that in the visual mode *S*s apparently remembered something more than the meaning of the sentence - also something about its length. Second, whereas in the first experiment the meaning evoked by the sentences may be characterized as easily imageable or 'concrete'; the meaning of the sentences in the present study was not easily imageable or it was more 'abstract'. The distinction is the one made by Paivio (1969), and to avoid needless controversy over whether the sentences were easily imageable, it is asserted that the sentences in the present study were more difficult due to the unfamiliarity of the vocabulary and the relationships expressed (for example, *The arrogant attitude expressed in the speech led to immediate criticism*).

Subjects. The *S*s were 40 University of Alberta students enrolled in various Psychology courses or employed at the University during the summer, 1973. There were 19 male and 21 female *S*s, ranging in age from 17 - 28 with a mean age of 23 years.

Materials. The only changes in material consisted of changes in the themes. The four themes were again chosen intuitively without regard to their linguistic status. These themes and their derived sentences (ONES, TWOS, THREES, FOURS) are presented in Appendix D. All other material was similar to that described for Experiment 1.

Procedure. All *S*s were presented with the experimental task individually. The procedure consisted of an acquisition and recognition phase and the study was conducted entirely in the aural mode.

Design. The *S*s were arbitrarily assigned to 4 experimental conditions varying Acquisition List (B, acquisition list 1, 2), and Recognition Order (C, recognition order 1, 2) orthogonally. During recognition each *S* rated all sentences from each of the four Themes (E). One-half of these recognition sentences belonging to each theme were from the acquisition list "old", whereas the remaining sentences had never been presented in acquisition and hence were "new" sentences (O, Old/New Sentences). In addition, the length of both old and new sentences was varied 1 - 4 ideas (L, Sentence Length), and several instances ("replication") of each sentence length were tested for recognition. The last factor which was not completely crossed with Sentence Length (see Table 1) was treated as a dummy variable. Thus the design may be characterized as a 2 x 2 x 4 x 2 x 4 x (2) factorial design with repeated measures over the last four factors.

Analysis. The initial analysis was performed on a 2 x 2 x 4 x 2 factorial design collapsing confidence ratings across Sentence Length and "replication" in order to assess the effect of Themes upon the recognition of Old/New Sentences. In the absence of significant Theme effects, this factor could be eliminated from the following analysis.

A subsequent analysis consisted of a 2 x 2 x 2 x 4 factorial design collapsing confidence ratings across Themes and "replications" to assess the effect of Sentence Length upon the recognition of Old/New Sentences. In both analyses each data point was based on the mean confidence ratings either across Sentence Length and "replication" or Themes and "replications". The two analyses were required because Sentence Length was not completely crossed with Themes (see Table 1).

Results. Tabulation of recognition confidence ratings showed that of the 1920 (40 *S*s x 48 sentences, excluding non-case sentences) responses only about 7.0% were negative confidence ratings and all these were to new sentences expressing a single idea (ONES).

The initial analysis showed no significant effects for Themes and a factorial analysis of variance for Sentence Length, collapsed over Themes, was performed. These results are presented in Table 3. The Old/New sentence x Sentence Length (OL) significant interaction is presented in Figure 7.

It was evident from Figure 7 that the Old/New sentences x Sentence

Length significant interaction was the result of differential recognition confidence ratings for sentences expressing a single idea (ONES). Regardless of the acquisition list, old ONES received higher recognition confidence ratings than new ONES. However, both old and new ONES received positive recognition confidence ratings. Thus while *S*s were able to distinguish old ONES presented in acquisition from new ONES which were never seen before, this finding must be qualified insofar as new ONES were not recognized as novel sentences but received positive, albeit low, recognition confidence ratings. That is, they were rated as old sentences.

However, regardless of acquisition sentences, *S*s were unable to distinguish old from new sentences when these expressed two, three, or four ideas. Therefore *S*s' ability to distinguish old from new sentences was restricted to ONES. It should be noted that all four theme sentences of which only two were presented in acquisition, and all 12 THREES of which only 8 were presented in acquisition received similar recognition confidence ratings dependent, of course, on sentence length. That is, sentences with combinations of relations which were entirely novel received the highest recognition confidence ratings. These findings confirmed those found in Experiment 1.

The significant effects due to Sentence Length were clearly the result of the finding that recognition confidence ratings were ordered: FOURS>THREES>TWOS (Figure 7). That is, recognition confidence ratings were a function of the number of ideas expressed in each sentence relative to the semantic content expressed in the theme sentences. However, this function was not "linear" nor was the slope of the curve quite as steep as might be expected on the basis of results in Experi-

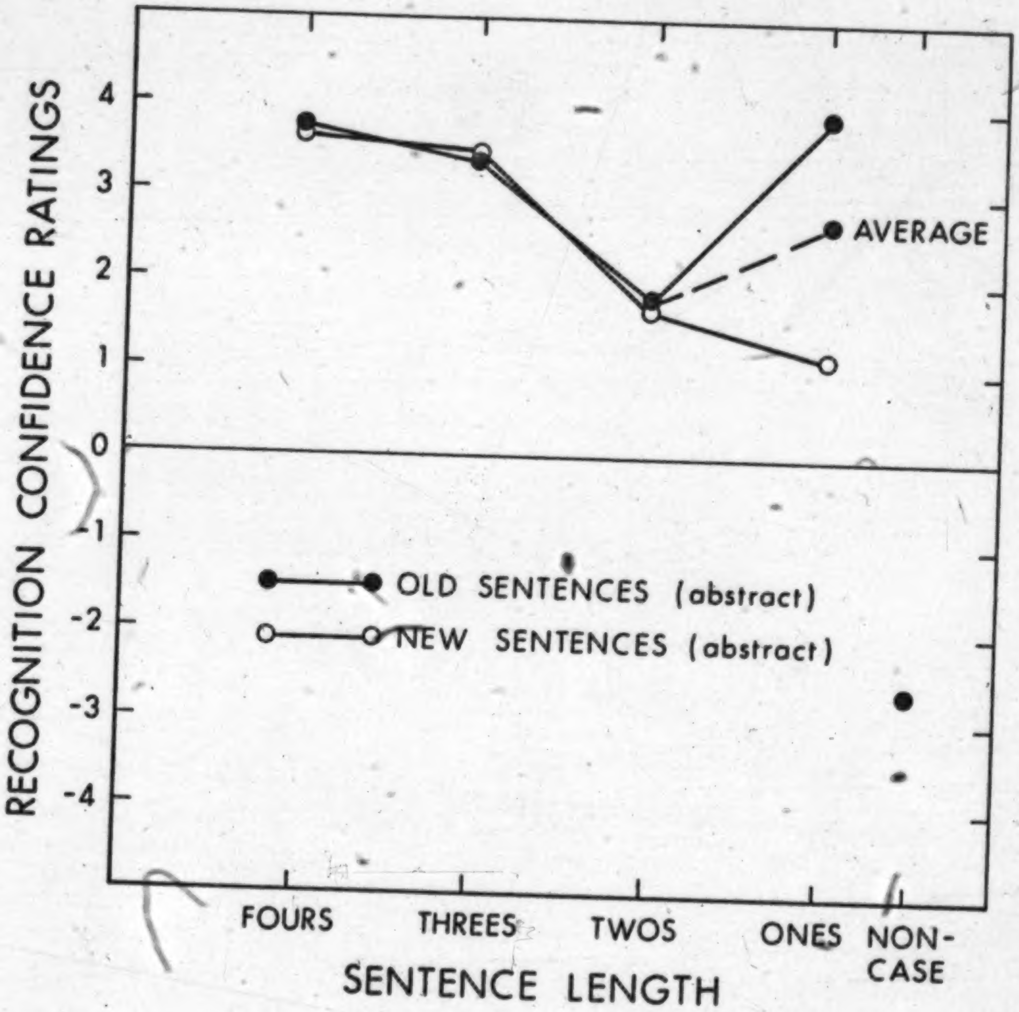
Table 3.

Experiment 2 results of the Analysis of Variance for Acquisition List (B) x Recognition Order (C) x Subjects (S(BC)) x Old/New Sentences (O) x Sentence Length (L) Factorial design.

Source of Variance	Mean Squares	Error Term	d.f.	F
B List	1.1112	BC	1	.28
C Order	5.9413	S(BC)	1	3.24
O Old/New	35.6264	CO	1	16.06
L Length	38.9301	CL	3	12.61*
BC	3.9074	S(BC)	1	2.13
BO	.5254	BCO	1	0.15
CO	2.2171	SO(BC)	1	2.02
BL	1.0555	BCL	3	1.30
CL	3.0863	SL(BC)	3	2.16
OL	35.3337	COL	3	11.77*
S(BC) Subjects	1.8282		16	
BCO		SO(BC)	1	3.19
BCL	0.8102	SL(BC)	3	0.56
BOL	0.6352	BCOL	3	0.24
COL	3.0019	SOL(BC)	3	2.09
SO(BC)	1.0962		16	
SL(BC)	1.4283		48	
BCOL	2.5960	SOL(BC)	3	1.81
SOL(BC)	1.4338		48	

**p<0.01 *p<.05

Figure 7. Recognition confidence ratings for the Old/New Sentences x Sentence Length interaction in Experiment 2.



ment 1. Thus in comparison to the results obtained in Experiment 1, *S*s gave relatively lower recognition confidence ratings to FOURS and TWOS with the consequent curvilinear relation between sentence length and confidence ratings. In fact, the recognition confidence rating difference between FOURS and THREES was not statistically significant ($p>0.10$), indicating that *S*s were unable to distinguish the number of ideas in THREES and FOURS sentences. Also consistent with the result in Experiment 1, recognition confidence ratings for ONES were a function of whether or not these were old or new sentences. Old ONES received confidence ratings which surpassed those for theme sentences, whereas confidence ratings for new ONES were such as to extend the ordering relation: FOURS>THREES>TWOS>ONES (new sentences). Nevertheless, as was noted above, even these new ONES received positive recognition confidence ratings.

All *S*s rejected non-case sentences which were not consonant with any of the relations expressed by acquisition sentences (Figure 7). However, in contrast to the results in Experiment 1, *S*s were less certain of their negative recognition confidence ratings for these non-case sentences which, it may be argued, was consistent with their lower positive confidence ratings for theme sentences. That is, the range of recognition confidence ratings for abstract linguistic material is more restricted than for sentences in Experiment 1.

In summary, *S*s were unable to partition old from new sentences with the exception of sentences expressing a single idea (ONES). *S*s were able to partition old from new sentences for the set of ONES, however, both old and new sentences received positive recognition confidence ratings. Recognition confidence ratings were ordered: FOURS>THREES>

TWOS>ONES (new sentences only), and non-case sentences were rejected.

Experiment 3

The third experiment was formally identical to the first two studies, with the exception that the linguistic material was of such a nature that the lexical items (both nominal and relational constituents) within each theme could be easily represented in pictorial form. In this third study two conditions were employed: first, the acquisition material was presented in pictorial form and the recognition material in linguistic form; second, the acquisition material was presented in linguistic form and the recognition material in pictorial form. The pictorial mode of presentation necessitated that the entire study be conducted in the visual mode. Thus it was expected that *S*s would acquire the theme on the basis of experience with pictorial material and be able to recognize novel sentences in the linguistic form, and the converse.

Subjects. The *S*s were 40 University of Alberta students enrolled in an introductory Psychology course during the Fall, 1973. There were 31 female and 9 male *S*s ranging from 17 - 20 years of age with a mean age of 18 years.

Materials. Four themes were constructed each consisting of three place specifying adverbials with respect to some object. Thus each theme consisted of a nominal constituent and a modifying predicate composed of three place-specifying prepositional phrases. The latter were conceptually so restricted that the content could easily be represented in pictorial form. In constructing these themes the place specifying adverbials designated a relationship of inclusion. The latter conformed to the principle that "Place specifying adverbials in the English sentence (where inclusion is involved) are ordered away from the predicate such that those which denote included space precede those which denote including space" (Oller and Sales, 1969, p. 229). (For example, *The bent key is on the oval ring in the right hand of the far man*). Each theme could be broken into four declarative sentences predicating the adjective to each noun (for example, *The key is bent*). In turn these four could be combined such that each phrase (adjective-noun) could be predicated on its preceding included object (Adjective-noun). This yielded three sentences containing a single relationship of inclusion (for example, *The bent key is on the oval ring*). Similarly, two sentences could be constructed containing two relations of inclusion (for example, *The bent key is on the oval ring in the right hand*). Finally, a single sentence, the theme, contained three relations of inclusion (for example, *The bent key is on the oval ring in the right hand of the fat man*). The four themes and derived sentences are presented in Appendix E. Thus each theme was defined by four sentences expressing the modifying relation of each place adverbial (ONES), three sentences expressing a single relation of inclusion (TWOS), two sentences expressing two relations of inclusion (THREES), and a single sentence expressing three relations of inclusion (FOURS), the latter being the theme. In addition four NON-CASE sentences were constructed by combining information across themes maintaining the principle of inclusion. Each NON-CASE sentence expressed information contained in sentences expressing two relations of inclusion (THREES above).

Each of the ten sentences derived from each theme, including the theme sentence, and each of the non-case sentences was typed on a 5 in.

by 8 in. index card. In addition, India Ink pen drawings were made of each idea expressed by these sentences on 5 in. x 8 in. index cards.[4] A sample theme is provided in Appendix F.

Procedure. All *S*s were presented with the experiment individually. However several changes were made in the procedure from the first two studies. The acquisition task was not presented as a short term memory task. Thus, there was no intervening colour naming task and *S*s were not required to respond verbally or in writing during the acquisition phase. The recognition phase was procedurally identical to that employed in the first two studies.

Acquisition. The instructions for the pictorial-acquisition/sentential recognition conditions were as follows: The *E* indicated that the *S* was to be shown a series of picture which represented ideas, he asked that the *S* carefully examine each picture and inquire if the idea was not clear. In case the latter occurred, the *E* in turn asked the *S* what he thought the picture was, and if the correct answer was obtained the procedure continued. In case of a wrong answer the *S* was eliminated from the study. That is, the *E*, during the acquisition phase, never pronounced the idea.

The instructions for the acquisition-sentential/recognition-pictorial conditions were as follows: The *E* indicated that a series of sentences would be read to the *S* and that he was to focus on the meaning of each sentence. While this presents a slight departure from the instructions of the two previous studies, it was deemed necessary given the pictorial nature of the recognition material.

Two sets of acquisition sentences and pictures were constructed. Each list contained 20 sentences or pictures, 5 related to each of the four themes. Because there are only nine acquisition sentences available from each theme (the theme sentence is excluded from acquisition), the two acquisition lists overlap by one sentence from each theme, that is, by a total of four sentences. These overlapping sentences were always sentences expressing a single relation of inclusion. Table 4 shows the number of each type of sentence or picture (expressing ONE, TWO or THREE ideas) used to construct each acquisition list. In contrast to the first two experiments, neither acquisition list contained sentences or pictures expressing the entire theme (FOUR ideas). The arrangement of each sentence acquisition list is presented in Appendix G.

Table 4.

Composition of the two acquisition lists for Experiment 3.

	Themes							
	Theme 1		Theme 2		Theme 3		Theme 4	
Ideas	Acq. 1	Acq. 2	Acq. 1	Acq. 2	Acq. 1	Acq. 2	Acq. 1	Acq. 2
THREES	1	1	1	1	1	1	1	1
TWOS	2	1	1	2	2	1	1	2
ONES	2	2	2	2	2	2	2	2

Recognition. The recognition list consisted of all 40 sentences or pictures, 10 related to each of the four themes. Thus *S*s who received acquisition list 1 (sentences or pictures) received both this list (pictures and sentences respectively; OLD ideas) and acquisition list 2 (pictures and sentences respectively; NEW ideas). Similarly, *S*s who received acquisition list 2 (sentences or pictures) received both this list (pictures and sentences respectively; OLD ideas) and acquisition list 1 (pictures and sentences respectively; NEW ideas). The recognition list also contained six NON-CASE sentences giving a total of 46 sentences. The recognition list was presented in one of two recognition orders, 1 - 46, 46 - 1. Again, selection order of the acquisition list was according to the constraints described in the previous two studies.

Design. The *S*s were arbitrarily assigned to 8 experimental conditions varying Mode of Presentation (A, acquisition pictorial/recognition linguistic and acquisition linguistic/recognition pictorial, Acquisition List (B, acquisition list 1, 2), Recognition Order (C, recognition order 1, 2) orthogonally. During recognition each *S* rated all sentences/pictures from each of the four Themes (E). One-half of these recognition sentences/pictures from each theme were from the acquisition list "old", whereas the remaining sentences/pictures had never been presented in acquisition and hence were "new " sentences/pictures (O, Old/New Sentences/Pictures). In addition, the number of ideas in both old and new sentences/pictures was varied from 1 - 4 ideas (L, Sentence Length), and several instances ("replication") of each sentence/picture/"length" (see Table 4) were tested for recognition. The last factor was not completely crossed with sentence length was treated as a dummy variable. Therefore the experimental design may be characterized as a 2 x 2 x 2 x 4 x 2 x 4 x (2) factorial design with repeated measures over the last four factors.

Analysis. The initial analysis consisted of a 2 x 2 x 2 x 4 x 2 factorial design collapsing confidence ratings across Sentence Length and "replications", in order to assess the effect of Themes upon recognition of both Old/New Sentences/Pictures. If theme main effect and interactions were non-significant this factor could then be eliminated from the analysis.

A subsequent analysis consisted of a 2 x 2 x 2 x 2 x 4 factorial design collapsing confidence ratings across Themes and "replications" to assess the effect of Sentence/Picture Length upon the recognition of Old/New Sentences/Pictures. In both these analyses each data point was based on mean confidence ratings (observations) across Sentence/Picture Length and "replications" or across Themes and "replications". Again, the two separate analyses were required because Sentence/Picture Length was not completely crossed with Themes (see Table 4).

Results. Tabulation of recognition confidence ratings showed that of the 1760 (40*S*x x 44 sentences, excluding non-case sentences) responses only 18.0% were negative confidence ratings and all these were restricted to sentences expressing single ideas (ONES) in the language-acquisition/picture-recognition mode of presentation.

A factorial analysis of variance of themes showed a Mode of Presentation x Theme significant interaction (AE, F = 11.31, d.f., 3,3, $p<0.05$). An analysis of the mean values under these two factors indicated that *S*s in the language-acquisition/picture-recognition mode of presentation gave lower recognition confidence ratings to sentences in the first two themes. These results are presented in Table 5.

Table 5

Mean recognition confidence ratings for the Mode of Presentation x Theme interaction in Experiment 3.

Mode of Presentation	(E) Theme 1	(E) Theme 2		(E) Theme 3	(E) Theme 4
(A) Recognition sentences	3.74	3.70		3.72	3.76
(A) Recognition pictures	(0.35	0.38)	<	(0.58	0.60)

An examination of individual responses in themes 1, 2, and 3, 4, by *S*s revealed no consistent pattern either for individual *S*s or for particular pictures which may be responsible for this effect. Hence, this significant interaction must be the result of some peculiarity in the transcription of linguistic ideas to pictorial form. Needless to say this procedure was difficult at best, primarily because of the inherent ambiguity present in pictorial compared to linguistic material. Indeed, should this be the case, it may be expected that any theme differences would become apparent in the language-acquisition/picture-recognition mode of presentation. Recognition confidence rating differences between the two modes of presentation must be examined in terms of the Mode of Presentation x Sentence Length significant interaction (AL, see below). In any case, it was decided to collapse over themes and run a factorial analysis of variance for sentences length and these results are presented in Table 6.

The Acquisition List (B) significant main effect and the Acquisition List x Old/New Sentences (BO) significant interaction were examined in terms of the significant 3-way interaction (Acquisition List

Table 6.

Experiment 3 results of an Analysis of Variance for Mode of Presentation (A) x Acquisition List (B) x Recognition Order (C) x Subjects S(ABC)) x Old/New Sentences (O) x Sentence Length (L) factorial design.

Source of Variance	Mean Square	Error Term	d.f.	F
A Mode	419.0344	AC	1	1435.54**
B List	1.1173	BC	1	211.88*
C Order	0.1828	S(ABC)	1	1.13
O Old/New	0.0344	CO	1	3.13
L Length	273.9514	CL	2	3081.50**
AB	0.0707	ABC	1	0.99
AC	.2919	S(ABC)	1	1.80
BC	.5272	S(ABC)	1	0.03
AO	.0004	ACO	1	0.04
BO	1.8594	BCO	1	18594.00**
CO	.0110	SO(ABC)	1	0.07
AL	549.3516	ACL	2	19619.70**
BL	0.1268	BCL	2	3.47
CL	0.0889	SL(ABC)	2	0.41
OL	0.0057	COL	2	0.11
ABC	0.0708	S(ABC)	1	0.43
ABO	0.7950	ABCO	1	14.33
ACO	0.0107	SO(ABC)	1	0.07
BCO	0.0001	SO(ABC)	1	0.00
ABL	0.5070	ABCL	2	3.71
ACL	0.0280	SL(ABC)	2	0.13
BCL	0.0365	SL(ABC)	2	0.17
AOL	0.0031	ACOL	2	0.17
BOL	2.3146	BCOL	2	257.17**
COL	0.0478	SOL(ABC)	2	0.45
S(ABC) Subjects	0.1616		32	
ABCO	0.0055	SO(ABC)	1	0.04
ABCL	0.1363	SL(ABC)	2	0.64
ABOL	0.1065	ABCOL	2	1.61
ACOL	0.0180	SOL(ABC)	2	0.17
BCOL	0.0090	SOL(ABC)	2	0.08
SO(ABC)	0.1490		32	
SL(ABC)	0.2128		64	
ABCOL	0.659	SOL(ABC)	2	0.62
SOL(ABC)	0.649		64	

**p<0.01 *p<0.05

x Old/New Sentences x Sentence Length, BOL) presented in Table 7.

Table 7

Mean recognition confidence ratings for the Acquisition List x Old/New Sentence x Sentence Length (BOL) interaction in Experiment 3.

(O) Old Sentences (Acquisition list 1 sentences)	(L) ONES	(L) TWOS	(L) THREES	(L) FOURS*
(B) Acquisition list 1	0.29	2.98	4.08	4.81
(B) Acquisition list 2	0.36	3.00	3.83	4.67

(O) New Sentences (Acquisition list 2 sentences)	(L) ONES	(L) TWOS	(L) THREES	(L) FOURS
(B) Acquisition list 1	0.21	2.96	3.80	4.14
(B) Acquisition list 2	0.16	2.90	3.98	4.27

*None of the four theme sentences had been presented in acquisition.

The Acquisition List x Old/New Sentences significant interaction (BO) showed that *S*s who received acquisition list 1 sentences/pictures gave higher recognition confidence ratings to these pictures/sentences (old sentences/pictures) than to acquisition list 2 pictures/sentences (new sentences/pictures) in recognition. Similarly, those *S*s who received acquisition list 2 sentences/pictures gave higher recognition confidence ratings to these pictures/sentences (old sentences/pictures) than to acquisition list 1 pictures/sentences (new sentences/pictures) in recognition. Hence, it may be concluded on the basis of this interaction alone that *S*s were able to distinguish old from new sentences/pictures in recognition as a function of acquisition list. However, this conclusion must be qualified in the light of the results depicted in Table 7. Thus, while none of the comparisons in Table 7 were statistically significant (Duncan's Multiple Range Test, $p>0.10$), *S*s presented with acquisition list 1 sentences/pictures gave higher confidence ratings to these pictures/sentences than to new pictures/sentences only for THREES and FOURS and in fact gave lower confidence ratings to old pictures/sentences when these were ONES and TWOS. Similarly, those *S*s who were presented with acquisition list 2 sentences/pictures gave higher confidence ratings to these pictures/sentences than to new pictures/sentences when they were THREES and FOURS, but gave higher confidence ratings to new pictures/sentences when these were ONES and TWOS. Thus while *S*s gave higher recognition confidence ratings to old sentences/pictures, the multiple comparisons were not statistically significant and the results obtained only for THREES and FOURS. It must be pointed out that these findings with respect to FOURS is somewhat puzzling, since all FOURS were novel sentences or pictures. That is, unlike Experiments 1, 2, and 4 none of the theme sentences/pictures in Experiment 3 had been presented in acquisition and hence recognition confidence ratings for theme sentences/pictures should have been independent of acquisition list and, of course, of the Old/New Sentence/Picture factor. Furthermore, *S*s actually gave higher confidence ratings to new sentences/pictures when these were ONES and TWOS, although again these results were not statistically significant. Finally, it should be noted that by collapsing over Mode of Presentation (A), all sentences and pictures received positive recognition confidence ratings, that is, *S*s believed all ideas to have been presented in acquisition.

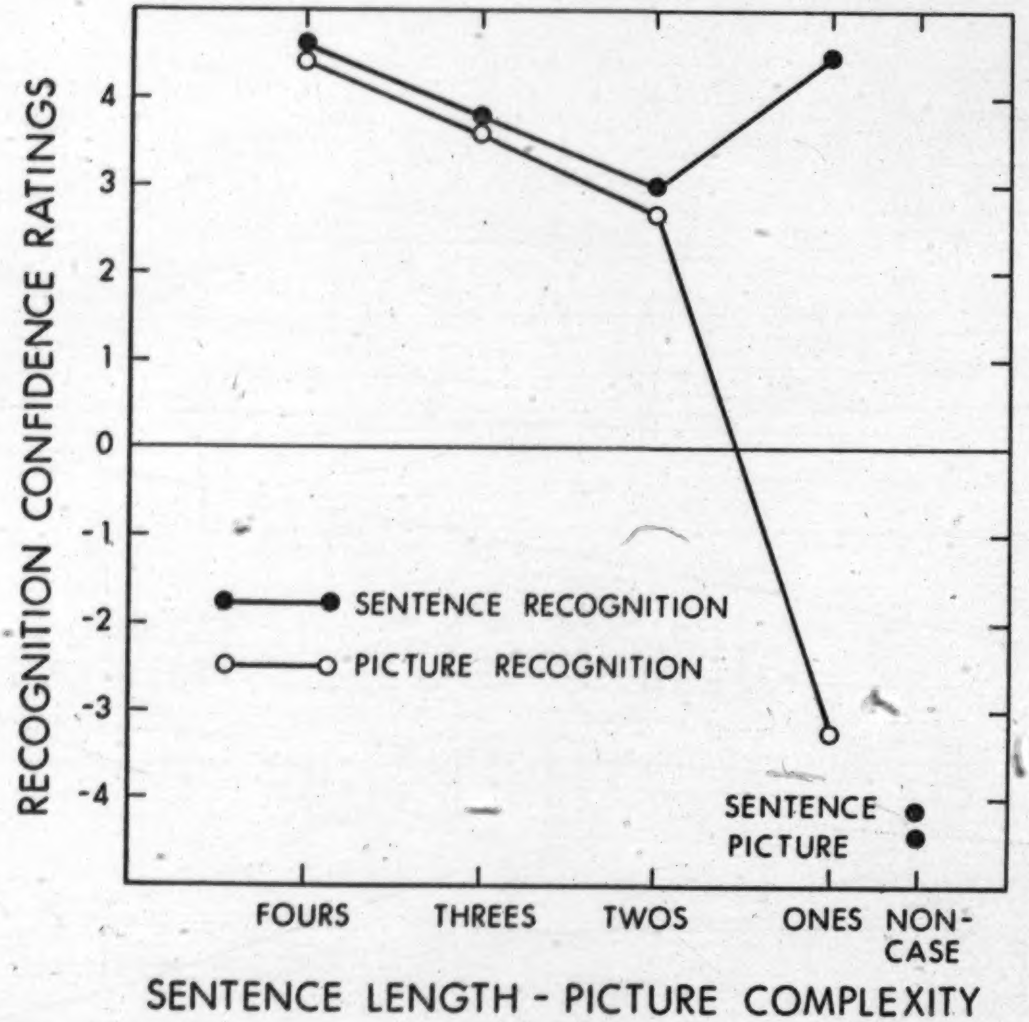
However, this finding must be qualified in view of the Mode of

Presentation x Sentence Length (AL) significant interaction depicted in Figure 8. By collapsing across both acquisition list and old/new sentences it was clear that recognition confidence ratings were ordered: FOURS>THREES>TWOS. That is, confidence ratings were a function of the number of ideas contained in each sentence or picture relative to the semantic content of theme ideas. This ordering relation is interrupted by the recognition confidence ratings results for ONES. Thus regardless of whether these were old or new sentences, single ideas expressed as sentences were given high positive recognition confidence ratings, whereas single ideas expressed as pictures were given high negative recognition confidence ratings. That is, *S*s were sure that both old and new sentences had been presented as pictures in acquisition and their ratings matched those for theme sentences. However, *S*s were sure that both old and new pictures had never been presented in acquisition as sentences and their confidence ratings matched those for non-case sentences. In striking contrast to Experiment 1 results, these findings were not dependent upon whether the ONES were old or new sentences/pictures.

In addition, the Mode of Presentation x Sentence Length significant interaction also accounts for the difference between the two modes of presentation consistent across all four themes as depicted in Table 5. The low positive confidence ratings for pictures compared to sentences was due to the high negative confidence ratings for ONES in case of pictures, and high positive confidence ratings for ONES in case of sentences.

Finally, irrespective of whether recognition was for pictures or sentences, *S*s in both modes of presentation rejected sentences/pictures

Figure 8. Recognition confidence ratings for the Mode of Presentation x Sentence Length/Picture complexity interaction in Experiment 3.



which were not consonant with any of the relations presented in acquisition. Non-case sentences and pictures received high negative recognition confidence ratings (Figure 8).

In summary, while there was some evidence that *S*s were able to distinguish old from new sentences/pictures, this obtained only for THREES and indeed new ONES and TWOS (sentences and pictures) actually received higher recognition confidence ratings than old sentences and pictures. *S*s recognition confidence ratings were ordered as a function of the number of ideas contained in each sentence or picture. However, this ordering effect was interruped for ONES which received high positive confidence ratings for both old and new sentences in the sentence recognition mode, and high negative confidence ratings for both old and new pictures in the picture recognition mode. All *S*s recognized non-case sentences and pictures as expressing new ideas.

Experiment 4.

This experiment was formally identical to Experiment 1, including the lexical content of the sentence. The only change made in this study was that the acquisition list sentences were presented in Dutch and recognition list sentences in English, and the converse. Therefore *S*s acquired the ideas in one language and were required to recognize sentences in another language. Translation of the English sentences employed in Experiment 1 into the Dutch language was a straightforward matter using several fluent bilinguals to affirm the correctness of the translation.

Subjects. Thirty-two bilingual *S*s were carefully selected. The following criteria were used to define bilingual *S*s. First, *S*'s native language was to be Dutch. Second, *S*s were required to be active readers of the Dutch language. Third, *S*s were required to have completed a degree at an English speaking University or be employed at a professional level. The *S*s ranged from 25 - 65 years of age with a mean of 36 years.

Procedure. The procedure was identical to that employed in Study 1. The only exception was that the intervening task during the 15 minute delay between acquisition and recognition consisted not of reading a standard passage, but rather of examining a book of photographs of paintings. This change in procedure was thought to be relatively neutral between the two languages and more appropriate to age and status of the *S*s. The entire study was carried out in the visual mode to avoid potential difficulties due to speaker accent. (A translation of the four themes is presented in Appendix H.)

Design. The *S*s were arbitrarily assigned to 8 experimental conditions varying Mode of Presentation (A, acquisition English/recognition Dutch and acquisition Dutch/recognition English), Acquisition List (B, acquisition list 1, 2), Recognition Order (C, recognition order 1, 2) orthogonally. During recognition each *S* rated all sentences from each of the four Themes (E). One-half of these recognition sentences were from the acquisition list "old" (in the other language) while the remaining sentences had never been presented in acquisition and hence were "new" sentence (O, Old/New Sentences). In addition, the length of both old and new sentences was varied from 1 - 4 ideas (L, Sentence Length), and several instances ("replications") of each sentence length (see Table 1) were tested for recognition. The last factor which was not completely crossed with sentence length was essentially treated as a dummy variable. Therefore the experimental design consisted of a 2 x 2 x 2 x 4 x 2 x 4 x(2) factorial desgin with repeated measures over the last four factors.

Analysis. The initial analysis was performed on a 2 x 2 x 2 x 4 x 2 factorial design collapsing confidence ratings across Sentence Length and "replications" in order to assess the effect of Themes upon recognition of Old/New Sentences. The absence of significant Theme main effect and interactions would justify the elimination of this factor from the subsequent analysis.

This analysis consisted of a 2 x 2 x 2 x 2 x 4 factorial design collapsing confidence ratings across Themes and "replications" to assess the effect of Sentence Length upon the recognition of Old/New Sentences. In both these analyses each data point was based on mean confidence recognition ratings across Sentence Length and "replications" and Themes and "replications" respectively. The two separate analyses were required because Sentence Length was not completely crossed with Themes.

Results. Recognition confidence ratings showed that of the 1536 (32 *S*s x 48 sentences, excluding non-case sentences) responses only 17.0% were negative confidence ratings and these were primarily restricted to old and new sentences expressing a single idea (ONES) in the Dutch recognition mode.

Since neither the main effect nor interactions with Theme were significant, a factorial analysis of variance for Sentence Length, collapsed over Themes, was justified. These results are presented in Table 8. The Acquisition List x Old/New Sentences x Sentence Length (BOL) significant interaction, which was similarly found in Experiment 3, is presented in Table 9.

While none of the comparisons in Table 9 are statistically significant (Duncan's Multiple Range Test, p>0.10), *S*s presented with

Table 8.

Experiment 4 results of an Analysis of Variance for Mode of Presentation (A) x Acquisition List (B) x Recognition Order (C) x Subjects (S(ABC)) x Old/New Sentences (O) x Sentence Length (L) factorial design. Experiment 4.

Source of Variance		Mean Square	Error Term	d.f.	F
A	Mode	290.1414	AC	1	2771.17**
B	List	0.0612	BC	1	6.57
C	Order	0.0082	S(ABC)	1	0.02
O	Old/New	0.0445	CO	1	1.65
L	Length	180.7421	CL	3	3666.10**
AB		0.0022	ABC	1	0.07
AC		0.1047	S(ABC)	1	0.31
BC		0.0092	S(ABC)	1	0.02
AO		0.0362	ACO	1	12.75
BO		0.3682	BCO	1	3.96
CO		0.0265	SO(ABC)	1	0.17
AL		190.1926	ACL	3	4914.50**
BL		0.0474	BCL	3	1.57
CL		0.0493	SL(ABC)	3	0.22
OL		0.0694	COL	3	0.99
ABC		0.0307	S(ABC)	1	0.09
ABO		0.0430	ABCO	1	1.75
ACO		0.0028	SO(ABC)	1	0.01
BCO		0.0928	SO(ABC)	1	0.59
ABL		0.1096	ABCL	3	13.20*
ACL		0.0387	SL(ABC)	3	0.17
BCL		0.0301	SL(ABC)	3	0.13
AOL		0.0336	ACOL	3	2.67
BOL		0.1235	BCOL	3	20.24*
COL		0.0699	SOL(ABC)	3	0.51
S(ABC)	Subjects	0.3307		24	
ABCO		0.0245	SO(ABC)	1	0.15
ABCL		0.0083	SL(ABC)	3	0.03
ABOL		0.0809	ABCOL	3	0.64
ACOL		0.0125	SOL(ABC)	3	0.09
BCOL		0.0061	SOL(ABC)	3	0.04
SO(ABC)		0.1563		24	
SL(ABC)		0.2161		72	
ABCOL		0.1252	SOL(ABC)	3	0.91
SOL(ABC)		0.1365		72	

**p<0.01 *p<0.05

Table 9.

Mean recognition confidence ratings for the Acquisition List x Old/New Sentences x Sentence Length (BOL) interaction in Experiment 4.

(O) Old Sentences (Acquisition list 1 sentences)	(L) ONES	(L) TWOS	(L) THREES	(L) FOURS
(B) Acquisition list 1	0.80	(2.99)	3.71	4.90
(B) Acquisition list 2	0.90	2.77	3.64	4.75

(O) New Sentences (Acquisition list 2 sentences)	(L) ONES	(L) TWOS	(L) THREES	(L) FOURS
(B) Acquisition list 1	0.21	2.96	3.80	4.14
(B) Acquisition list 2	0.16	2.90	3.98	4.27

acquisition list 1 sentences gave higher recognition confidence ratings to these sentences in recognition (old sentences) than to new sentences for TWOS, THREES, and FOURS, but gave higher confidence ratings to new sentences when these were ONES. Similarly, *S*s presented with acquisition list 2 sentences gave higher confidence ratings to these sentences (old sentences) than to new sentences for THREES and FOURS, but gave higher confidence ratings to new sentences when these were ONES and TWOS. This pattern of results is very similar to the findings reported in Table 7 for Experiment 3. However, in contrast to study 3, in the present study 2 of the 4 theme sentences had been presented in acquisition. Examination of individual sentences showed that these findings were entirely due to somewhat lower recognition confidence ratings for the 2 FOURS and 4 THREES which were novel, that is expressed relations never before presented in any one of the acquisition list sentences. However, it is notable that new ONES and TWOS actually received higher recognition confidence ratings than old ONES and TWOS. Thus, while it may not be concluded that *S*s can partition the set of old from new sentences, there was a slight preference for old THREES and FOURS which was independent of the mode of presentation (whether recognition was of Dutch or English sentences).

The Mode of Presentation (acquisition English or Dutch/recognition Dutch or English respectively) x Sentence Length (AL) significant interaction is presented in Figure 9. However, this interaction must be interpreted in terms of the Mode of Presentation x Acquisition List x Sentence Length (ABL) significant interaction, the results of which are presented in Table 10. Multiple comparisons among the means in Table 10 did not attain statistical significance ($p>0.10$) within either mode of presentation or under any particular sentence length (Duncan's Range Test).

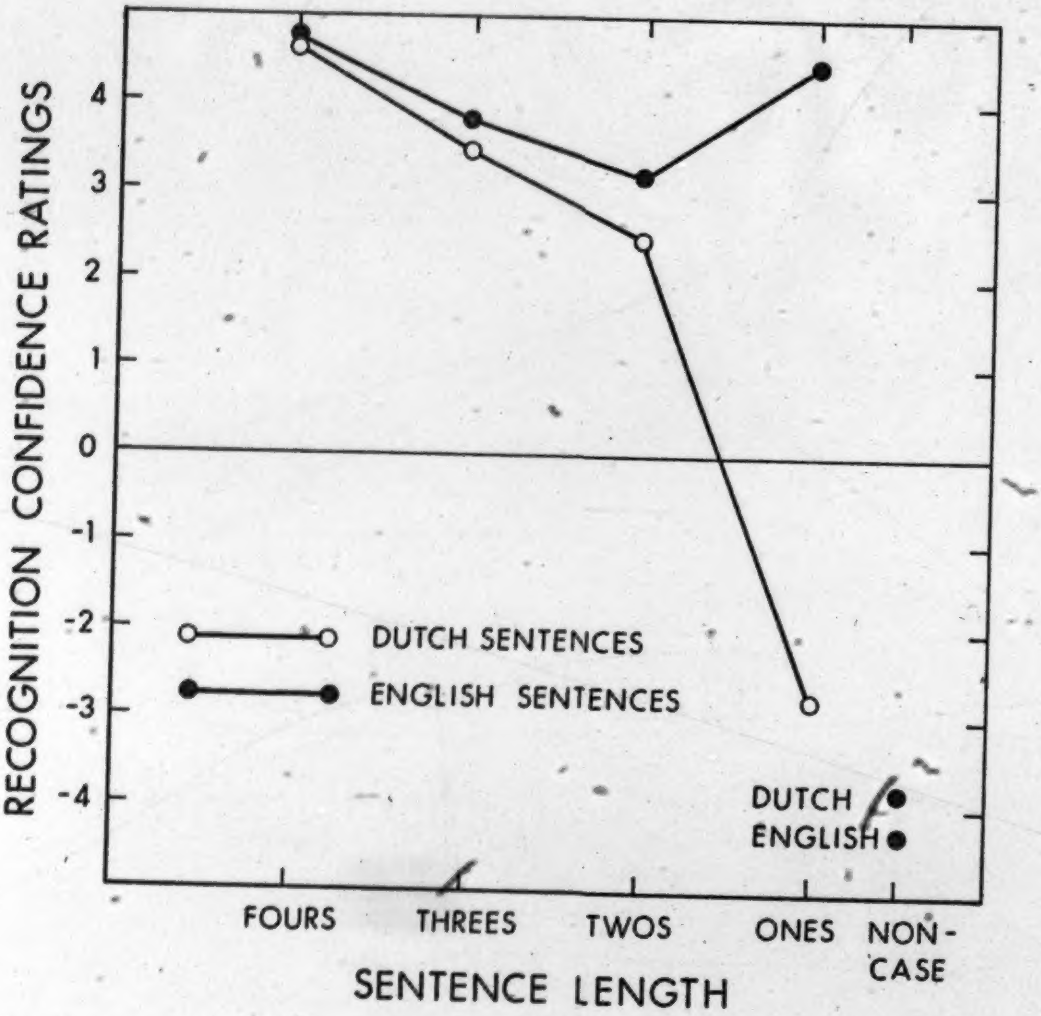
Table 10.

Mean recognition confidence ratings for the Mode of Presentation x Acquisition List x Sentence Length (ABL) interaction in Experiment 4.

(A) Dutch recognition	(L) ONES	(L) TWOS	(L) THREES	(L) FOURS
(B) Acquisition list 1	4.54	3.20	3.97	4.84
(B) Acquisition list 2	4.43	3.21	4.02	4.90

(A) English recognition	(L) ONES	(L) TWOS	(L) THREES	(L) FOURS
(B) Acquisition list 1	-2.83	2.47	3.48	4.81
(B) Acquisition list 2	-2.75	2.59	3.52	4.71

Figure 9. Recognition confidence ratings for the Mode of Presentation x Sentence Length interaction in Experment 4.



As is evident from Table 10, *S*s in the Dutch recognition mode who received acquisition list 1 sentences in English gave somewhat higher recognition confidence ratings to these sentences in Dutch when these were TWOS, THREES and FOURS regardless of whether these were old or new sentences. Similarly, *S*s in the English recognition mode who received acquisition list 1 sentences in Dutch gave somewhat higher recognition confidence ratings to these sentences in English when these were TWOS and THREES regardless of whether these were old or new sentences. However, as there appeared to be no consistent pattern among these findings, the results were not statistically significant, and there was no theoretical reason for this preference, the signficicant Mode of presentation x Sentence Length interaction may be taken as the focal finding (Figure 9).

As is clear from Figure 9, recognition confidence ratings were ordered: FOURS>THREES>TWOS. That is, consistent with the three previous studies, recognition confidence ratings were a function of the number of ideas contained in each recognition sentence whether in English or Dutch relative to the semantic content of theme sentences. However, very much like the findings in Experiment 3, this ordering relation was interrupted for ONES. *S*s who received the acquisition sentences in Dutch and the recognition sentences in English gave high positive confidence ratings to ONES regardless of whether these were old or new sentences. In fact these confidence ratings matched those given to theme sentences. However, *S*s who received acquisition sentences in English and recognition sentences in Dutch gave high negative confidence ratings to both old and new ONES. Notably, these ratings were not as high as the ratings by *S*s in both modes of presentation for non-case sentences.

Finally, regardless of whether recognition was in Dutch or English, *S*s rejected sentences which were not consonant with any of the ideas presented in acquisition. Non-case sentences received high negative recognition confidence ratings, that is, were treated as new sentences (Figure 9).

In summary, while there was some evidence that *S*s were able to distinguish old from new sentences particularly with respect to THREES and FOURS, there was also some indication that *S*s actually gave higher confidence ratings to new ONES and TWOS. In any case, none of these findings were statistically significant. Furthermore, irrespective of acquisition list or whether sentences were old or new, all sentences, with the exception noted below, received positive recognition confidence ratings. *S*s' recognition confidence ratings were ordered as a function of the number of ideas per sentence. However, *S*s who received recognition sentences in the Dutch language gave high negative confidence ratings to both old and new ONES, whereas, *S*s who received English recognition sentences gave these ONES high positive confidence ratings. All *S*s recognized non-case sentences, whether in Dutch or English, as new sentences.

7

CHAPTER 9

DISCUSSION

Both theoretical considerations and a number of empirical studies have suggested that semantic information evoked or conveyed by sentences and connected discourse is stored in memory as a unified representation. Bransford & Franks (1971) proposed an experimental paradigm designed to test the validity of this claim. These authors interpret their results as consistent with the thesis that people spontaneously and constructively integrate and retain a unified semantic representation of the information obtained from a series of meaningfully related sentences. That is, they maintain that individual sentences have no unique status in memory in lieu of wholistic representation of semantic events, and they find that recognition memory for new sentences depends upon the extent to which the ideas expressed in these sentences exhaust the ideas expressed in these representations.

The purpose of the present studies was twofold. First, to replicate the Bransford & Franks (1971) findings in both the visual and auditory mode using readily imageable and non-imageable (abstract) sentential material. Thus where previous studies (Anderson & Bower, 1973; Bransford & Franks, 1971, 1973; Katz, 1973; Katz, Atkeson & Lee, 1973; Reitman & Bower, 1973) were conducted only in the visual mode, the phenomenon of semantic integration was similarly expected to occur in the linguistic primary auditory mode and to be relatively independent of the concrete-abstract dimension (Experiments 1 and 2). Second, to extend the Bransford & Franks research under the assumption that such wholistic representations are probably best conceived of neither as semantic and sequential nor imageable and spatial but as entirely abstract in nature.

The evidence for an abstract conceptual code was obtained using the same experimental paradigm in which pictorial and linguistic material in two different languages was factorially varied in the acquisition and recognition phase of the experiment (Experiments 3 and 4).

Specifically, the concern in all four studies was with the memory for wholistic ideas or abstract representations. It was assumed that the formation of these was the result of the constructive integration of information expressed by related sentences or pictures experienced successively but non-consecutively in time. Insofar as this assumption obtained the following results were expected. (1) *S*s should demonstrate evidence of 'productivity' and be unable in recognition memory to distinguish old from new ideas provided these are consonant with the acquired representation. (2) *S*s recognition confidence ratings of both sentences and pictures should reflect the extent to which any idea presented for recognition memory reinstates the acquired representation. (3) *S*s should be able to clearly distinguish ideas, whether expressed as sentences or pictures, which are not consonant with the acquired representation and their confidence ratings for these should reflect this capacity.

The results of these studies were remarkably similar with respect to these expectations. First, *S*s were unable to partition the set of recognition ideas (sentences and pictures) into non-overlapping sets of old and new ideas. That is, *S*s' recognition ratings reflected the belief that they had seen or heard both old and new ideas in acquisition, whereas in fact, they had seen or heard only old ideas. Especially striking was the finding that both old and new FOURS, THREES, and TWOS received similar positive recognition confidence ratings. These results were remarkable not only because one half of the ideas presented in recognition were new ideas, but because some of the new FOURS and THREES contained combinations of relations which the *S* had never experienced in any single acquisition sentence or picture. In fact, it was these ideas which received the highest recognition confidence ratings. The important consideration here stems from the conceptual distinction between comprehension as a constructive process of memory and rote memorization. Thus, these results are at variance with the rote memorization for specific events not only because new ideas which were consonant with the acquired themes received positive recognition confidence ratings, but because ideas which contained relations that were never experience at all received the highest recognition confidence ratings. These results support the hypothesis that what is learned involves the constructive integration of information from among particular events, and what is retained is some wholistic abstract representation of the results of this process and not the particular events themselves.

The latter is related to the second prediction above which pertains to the relationship between the number of ideas expressed in recognition sentences or pictures and the number of ideas contained in the acquired themes. These results from all four Experiments are presented in Figure 10. (All Figures referred to in the *Discussion* are presented in Appendix I.) What is notable is that recognition confidence ratings in all four studies were ordered: FOURS>THREES>TWOS>ONES>NON-CASE. These results confirmed the supposition that *S*s acquired something other than a list of sentences or pictures presented in acquisition. *S*s integrated the information expressed by sets of individual ideas, expressed as sentences or pictures, and constructed wholistic abstract representations of these. Recognition memory for both old and new ideas was mediated by and hence some function of these acquired themes or representations. That is, recognition confidence ratings for both old and new ideas were a function of the extent to which any particular recognition sentence or picture exhausted the information expressed in the acquired theme.

Finally, the fact that *S*s in all four experiments were very confident that they had not seen or heard non-case sentences or pictures indicates that the abstract conceptual code that *S*s acquired in acquisition had a considerable degree of precision. Therefore, it may be assumed that recognition confidence ratings were not based upon or mediated by the identity of individual words, spatial configurations, or even sequences of words, but upon stated and inferred relations among idea sequences. Clearly, comprehension and recognition memory involves the recovery of abstract structure meaning relations and not necessarily, if at all, perceived structure forms.

However, the results were not as definitive as all that and where these deviate from the above, they will be discussed separately for each experiment.

The results obtained in Experiment 1 conducted in the visual mode, which was a replication of previous research (Bransford & Franks, 1971, Experiment 3), were comparable to those reported by Bransford & Franks and Katz (1973). The findings from these three studies are presented in Figure 11. Apart from the magnitude of the absolute rating differences among these three studies, the striking result in the present study was the recognition confidence rating difference between old and new ONES. Thus *S*s were quite confident that they had previously seen old ONES, and similarly, quite confident that they had not seen new ONES. This finding was in contrast to the results reported in the two other studies. Thus Katz (1973) did not find his results dependent upon whether the sentences were old or new, and all his *S*s gave positive recognition confidence ratings to both old and new sentences. Whereas the Bransford & Franks' *S*s were able to discriminate in their confidence ratings between old and new ONES, both old and new ONES were recognized as new sentences.

The results of the present study can be readily accomodated under the assumption that *S*s remember something about the form of the sentence in addition to the abstraction of its meaning. This would appear to be a plausible hypothesis (*cf.* Reitman & Bower, 1973), given that the experiment was conducted in the visual mode wherein sentence length may be assumed a peculiarly salient feature of information processing.

The hypothesis that sentence form may be a contributing factor in recognition memory for sentence meaning was supported when these findings were compared to those obtained in the aural mode of presentation. Figure 12 compares the Bransford & Franks results in the visual mode with the present results in the aural mode. Whereas the magnitude of the difference between old and new ONES in these two studies was very similar, the magnitude of the difference between old and new ONES in the visual and aural mode in the present study may be accounted for entirely by the increased difficulty to discriminate or attend to form when the natural inclination must be to attend to the meaning of the sentence when it is spoken. It may be tentatively concluded that when sentential material is visually presented for comprehension, the opportunity to retain something about form in addition to meaning is greater than for the same material presented in the auditory mode.

Two considerations are relevant with respect to these findings. First, the attribute of form was salient only for ONES. This finding is not unreasonable if, as was assumed here, *S*s do indeed constructively integrate information from sentences and retain only some abstract representation of it, then ONES reinstate the least information derivable from the theme and were presumably more easily discriminated from TWOS, THREES, and FOURS than the latter were from each other. Second, the fact that ONES received extreme confidence ratings suggests that sentence form, which may be a more or less incidental feature of language depending upon the modality, in combination with sentence meaning can effectively disrupt the phenomenon of recognition memory for ideas. Whether the ideas expressed by ONES were stored with the constructed theme or as a simple list of sentences may be evaluated by increasing the acquisition-recognition interval to see if recognition memory for ONES is differentially affected from TWOS, THREES, and FOURS. The present study already increased the acquisition-recognition interval from 5 to 15 minutes over the previous studies simply to obtain the predicted results and replicate the basic phenomenon. It was therefore somewhat surprising that *S*s in these studies (Bransford & Franks, 1971, 1973; Katz, 1973; Katz, Atkeson & Lee, 1973) were unable to distinguish old from new ONES.

However, the present finding for ONES was consistent with the results reported by Katz, Atkeson, & Lee (1973). As will be recalled, these authors maintained that the "linear effect" was an artifact of the experimental paradigm and they found that when *S*s were presented with acquisition list sentences consisting only of ONES, these received recognition confidence ratings equal to the ratings for THREES and FOURS in the present study (see pp. 165-169, this thesis). The authors attributed *S*s' low recognition confidence ratings for both old and new ONES in previous studies (Bransford & Franks, 1971; Katz, 1973; Katz, Atkeson, & Lee, 1973) to confusion in recognition memory due to their inability to distinguish ideas presented in isolation from ideas embedded with other ideas. Now the present results indicate that confidence ratings for ONES do attain the same magnitude as confidence ratings for FOURS but only in case *S*s can distinguish old from new sentences otherwise the "linear effect" obtains. Whereas the present results do not preclude the claim that the "linear effect" is an artifact of the experimental paradigm, they do suggest an important restriction on this conclusion. That is, when listening and reading for comprehension without the explicit demand for memorization, what is distinctive and hence useful in the subsequent recognition memory for exact sentences is something about form and not just the meaning import of sentences. Therefore the "linear effect" is not, strictly speaking, an artifact of the paradigm at all, but rather a fact about the construction of a meaning representation where sentence form does not constitute a salient feature. This is a very different conclusion.

The finding that *S*s were able to partition the set of ONES into old and new sentences confirms the Reitman & Bower (1973) claim that *S*s do retain some specific exemplar information in addition to the acquisition of an "abstract principle" (see p. 157, this thesis). However, the present results do not support their findings, using letter and number strings rather than sentences, that *S*s were able to distinguish old from new strings irrespective of their length (see Figure 13). Since the results for old legal strings were remarkably similar to the findings for old and new sentences, the *S*s' ability to distinguish old from new legal strings was presumably a function of the nature of the stimulus material. This claim is consistent with the hypothesis that simpler information loads, notably the information conveyed spatially by letters and numbers, are translated into a visual code at which the visual modality is particularly adept (Pick, 1970).

Nevertheless, it may be that the results of the present study would be quite different were a forced choice procedure employed in recognition memory as proposed by Bower & Anderson (1973). However, even employing this forced choice procedure the authors found that *S*s were only able to distinguish old from new ONES and TWOS (to some extent), but were clearly unable to distinguish old from new THREES and FOURS (see p. 165 ff., this thesis). It should be evident that the forced choice procedure would facilitate discrimination on the basis of form more readily than in the paradigmatic recognition task, and hence these results support the present thesis.

Finally, while the recognition of non-case sentences as novel sentences cannot be accepted as definitive with respect to the construction of the abstract conceptual code (see Reitman & Bower, 1973), the results for non-case sentences confirmed previously reported findings. In view of the productivity exemplified in the recognition ratings for THREES and FOURS, the confidence ratings for non-case sentences provides additional evidence for the constructive integration of ideas and for the precision of such a representation of what is learned.

Experiment 2 was designed to evaluate the robustness of the results obtained in the first study, using instead of sentences that have a concrete and highly imageable semantic structure, sentences that have an abstract and presumably difficult-to-image semantic structure. The psychological reality of the abstract-concrete distinction proposed by Paivio (1969), was convincingly demonstrated in a series of studies that found recall memory for thematic concrete sentential material superior to recall memory for thematic abstract sentential material (Begg & Paivio, 1969; Pompi & Lachman, 1967; Yuille & Paivio, 1969). Begg & Paivio (1969) have suggested that concrete sentential material evokes an "organized unit" or "complex image" where the sentence is " ... transformed into a non-verbal code in which the information is stored spatially ... [whereas abstract sentential material] ... is assumed to remain linked more closely to sequential organized verbal units themselves and can be summarized as a non-verbal unit only with difficulty" (Begg & Paivio, 1969, p. 821). It was further assumed that lexical changes in concrete sentential material should have relatively little effect on the "complex image" and hence on recall memory, whereas changes in meaning would require reorganization of the image and hence have a relatively greater effect on recall memory. Conversely, for abstract sentential material lexical changes should have a relatively greater effect on recall memory since the " ... verbal sequential representation is tied to the motor acoustic pattern itself ...", whereas changes in meaning should go relatively unnoticed because the abstract sentential material is already a heavy burden on memory (sic). With perhaps somewhat different implications, this explanation maintains that abstract sentential material is simply more difficult to understand and retain than concrete sentential material (see Begg & Paivio, 1969).

Thus it may be argued that the assumed wholistic representations constructed in Experiment 1 were the result of the concrete nature of the linguistic material employed. While this claim would be contrary to the proposal that the meaning representation is entirely abstract, the image hypothesis could account for the predicted findings. Both the failure to distinguish old from new sentences and the linear ordering of sentence length can be handled by the assumption that changes in lexical items have little effect on the image representation. Similarly, the recognition of non-case sentences is consistent with the assumption that changes in meaning affect the organization of the constructed image. However, under the assumption that lexical as opposed to meaning changes have a relatively greater effect on abstract than concrete sentential material, we might anticipate very different results using abstract sentences in the Bransford-Franks experimental paradigm.

Clearly the results obtained in Experiment 2, using abstract sentential material, were similar to those found in Experiment 1, using concrete sentential material (see Figure 10). Figure 14 compares the results in the present study with those reported by Bransford & Franks (1973) for some pilot work using abstract sentences. Several points should be noted with respect to these findings. First, consistent with the results obtained in Experiment 1, absolute recognition confidence ratings in the aural mode in the present study were higher than those reported by Bransford & Franks (1973) in the visual mode. However, recognition confidence ratings for abstract sentences in both these studies were lower than those found for concrete sentences. Second, the recognition confidence range over Sentence Length was smaller in both these studies than the confidence range for concrete sentential material (compare Figures 11 and 14). Consistent with the narrow recognition confidence range for abstract sentences, non-case sentences received only intermediate negative recognition confidence ratings. That is, in contrast to the high negative confidence ratings for concrete non-case sentences in Experiment 1, *S*s in Experiment 2 were less confident that they had not previously seen abstract non-case sentences in acquisition. Third, whereas *S*s in the present study were able in their confidence ratings to distinguish old from new ONES [this was not the case in the Bransford & Franks (1973) study], in contrast to the results for ONES in Experiment 1, both old and new abstract ONES received positive recognition ratings. That is, all *S*s rated ONES as old sentences.

The pattern of results in the present study support those obtained in Experiment 1. Nevertheless, the constructed meaning representations were in some less explicit for the ideas abstracted from abstract than from concrete sentences. Thus *S*s in the present study were able to generate semantic structures from the acquired representations to match novel input structures with considerably less certainty than for concrete material. In fact the findings tend in the same direction as the results previously reported for the "unconstrained" condition (Bransford & Franks, 1973, see p. 151 ff., this thesis), and the "no concept" condition (Reitman & Bower, 1973, p. 160, ff., this thesis), and suggest that the wholistic representation is so abstract that it does not permit *S*s to discriminate novel semantic structures with the same degree of precision as for concrete sentences. Whereas these findings may be taken as supporting Paivio's thesis that recognition memory improves as a direct function of concreteness or imageability, the similarity between the results in Experiments 1 and 2 would suggest not. Also, any argument that the results support the contention that abstract material is simply more difficult to understand than concrete material (with the implied suggestion that the abstract representation was in some sense less complete for abstract sentences), must confront the evidence that *S*s were able to constructively integrate the meaning for abstract sentences as readily as for concrete sentences. Whether or not imageability was a factor in these results deserves continued study, but both the present results and those of Experiment 3 suggest not.

Experiment 3 was designed primarily to obtain evidence for the abstract nature of the conceptual code or representation and, secondarily, to evaluate the imagery hypothesis proposed by Paivio (1969). Thus if, as was assumed in the theoretical discussion above, the 'language' of thought is entirely abstract, the predictions which obtained for the abstraction of linguistic ideas should similarly hold for perceptual ideas. That is, recognition memory for either pictures or sentences should not depend upon the form in which ideas were expressed in acquisition and on the basis of which the conceptual code was constructed.

This is rather different from the proposal made by Paivio (1969). Thus, " ... objects or their pictorial representations arouse non-verbal perceptual images directly and, to the extent that such images facilitate the formation of associative connections with response members [reference to paired-associative learning] ... pictures should be even more effective than concrete nouns at least as stimulus members of pairs ..." (Paivio, 1969, p. 254). However " ... where learning has generally been easier when response nouns are concrete rather than abstract, pictures as response members are not facilitative in comparison with concrete nouns, possibly because the former involve a symbolic labelling or decoding problem" (Paivio, 1969, p. 255). On this account, recognition memory for sentences, given that theme acquisition occurred from ideas expressed in pictorial form, should yield results similar to those obtained in Experiment 1. However, recognition memory for pictures, given that theme acquisition occurred from ideas expressed in sentential form, should yield rather different results. Paivio is not quite clear what he intends by the "decoding problem", however it may be assumed that pictures are simply more ambiguous than sentences, and that any number of sentences are potentially consistent with a pictorial representation. In any case, in the present study we might expect recognition memory for sentences to be superior than for pictures. Similarly, since in the present study the form in which ideas are expressed is of no consequence to recognition memory, *S*s should be unable to distinguish old from new sentences even for ONES.

The results in Experiment 3 were remarkably similar to those obtained in Experiment 1, with the exception for recognition confidence ratings for ONES (see Figure 15). What was remarkable, of course, was the findings that these results obtained for both sentence and picture recognition. Before examining these results more closely, two minor experimentally dependent results should be noted. First, not all theme sentences appeared to be of equal difficulty in the picture recognition condition. Thus *S*s who were required to recognize ideas in pictorial form gave somewhat higher recognition confidence ratings to sentences belonging to two of the four themes. While there is no account for this finding, the fact that it occurred only in picture recognition memory suggests that picture recognition for ideas abstracted from sentential form may be a different task than sentence recognition of ideas abstracted from pictorial form. Second, there was a slight preference in both the picture and sentence recognition conditions for old THREES, and new ONES and TWOS. Again , this finding is somewhat puzzling but the fact that it occurred in both sentence and picture recognition suggests that it may be a peculiarity of the choice of ideas employed in the present study.

The major difference between the results in the present study and those obtained in Experiments 1 and 2 was with respect to the confidence ratings for ONES. Thus in the present study, *S*s were unable to distinguish old from new ONES; however, both old and new sentences (ONES) received high positive recognition confidence ratings, whereas both old and new pictures (ONES) received negative recognition confidence ratings (Figure 15). Subjects' inability to distinguish old from new ONES may be accounted for by the asymmetry between the form of idea expressed in acquisition and recognition, which would effectively eliminate form as a salient feature in recognition memory. In view of the instruction changes for recognition memory in the present study (from "actual sentence" to "same idea or meaning") and the asymmetry between acquisition and recognition form of the expressed ideas, the "linear effect" between sentence length or picture complexity and confidence ratings would appear to be a robust phenomenon and a function of the information processing characteristics of the abstract conceptual code. This conclusion and these findings are at variance with those reported by Katz (1973). Whereas Katz was able to replicate the Bransford & Franks results, he found that when he altered the recognition memory instructions to read "meant exactly the same thing" (Katz, 1973, p. 80), he was unable to replicate the linear ordering effect. Thus, while he found that *S*s were unable to distinguish between old and new sentences, he also found that they did not distinguish in their confidence ratings among sentence length. He attributed this finding to the change in instructions which directed *S*s away from the form of the sentence. Hence Katz attributes the "linear effect" to the demand for exact sentence recognition and therefore a function of form and not of semantic processing. However, the results of the present study, which necessarily employed the same instructions as did Katz, and which varied acquisition and recognition form, confirmed the "linear effect".

The differential recognition ratings for single ideas expressed as sentences and pictures, appeared to be consistent with Paivio's contention that imagery can serve an effective mediation function in the picture acquisition - sentence recognition but not in the sentence acquisition - picture recognition condition. Whereas the present results do not exclude the imagery hypothesis, the latter is restricted only to the findings for ONES. Certainly the parallel results obtained for FOURS, THREES, and TWOS in both the sentence and picture recognition conditions is inconsistent with any notion which maintains the differential effectiveness of imagery in meaning acquisition.

If, on the other hand, we retain the hypothesis that what is learned is in the nature of an abstract conceptual code, we may then assume that the abstraction of pictorial meaning results in a less explicit, more variable, conceptual structure than the abstraction of sentential meaning. In case of the former, the recognition memory for consonant sentential input should be rated as consistent with the acquired representation, whereas in case of the latter, recognition memory for consonant but very much more ambiguous pictorial material may be rated as inconsistent with the acquired representation. The difficulty with this admittedly *post hoc* explanation is that it fails to account for the degree of confidence expressed, either positive or negative, for sentential and pictorial ONES respectively. Thus how is it that both old and new pictures and sentences (ONES) received extreme confidence ratings albeit in opposite directions? The extreme confidence rating for pictures may be accounted for if it is assumed that the notion of ambiguity is a function of the extent to which a picture fails to exhaust the acquired abstract representation, in which case ONES would be most ambiguous and hence receive high negative recognition confidence ratings. Similarly, recognition confidence ratings for sentences, given the more variable nature of the abstract representation acquired from pictures, may be some curvilinear function of the extent to which ideas so expressed exhaust the abstract representation. Unfortunately, this account is rather speculative and not consistent with the findings of Experiment 4.

The results obtained in Experiment 4 provide additional support for the thesis that the nature of the conceptual code is abstract. Thus the pattern of results for both the Dutch and English recognition sentences closely parallel each other and the results obtained in the previous three studies. Experiment 4 required *S*s to construct the themes in one language and recognize sentences in another. Rather than assume a dual mediational code with some intermediate process of translation, it is more parsimonious to assume that the conceptual code is interlingual (Schank, 1972), which it would be under the assumption of abstractness. Therefore it must follow that translation does not occur between the stored meaning of two natural languages, but rather that translation is a more peripheral process which occurs between the natural language of the perceived structure and the conceptual 'language' of the abstract structure.

The results of Experiment 4 present some difficulties with respect to the interpretation of the findings for ONES. Figure 16 presents a comparison of the results obtained in Experiments 3 and 4. These are very similar. Subjects in both these experiments, in contrast to the findings in Experiments 1 and 2, were unable to distinguish old from new ONES; however, in the present study English recognition sentences received high positive recognition confidence ratings and Dutch recognition sentences received high negative recognition confidence ratings. Furthermore, English TWOS and THREES received somewhat higher recognition confidence ratings than their respective Dutch sentences. It is clear that any explanation in terms of imagery or variability of the acquired abstract structure is not applicable to the results in the present study.

A comparison of recognition confidence ratings in Experiment 4 with those obtained in Experiment 1 is presented in Figure 17. It will be recalled that the ideas employed in both these studies were identical. Notably, the results for Dutch sentences more closely matches the findings in Experiment 1. It may be assumed therefore that the results for English sentences in the present study were due to some peculiarity of conceptual abstraction in the Dutch language. That is, both Dutch acquisition - English recognition results differed from both English acquisition - Dutch recognition results in the present study and from English acquisition - English recognition results obtained in Experiment 1. Therefore theme construction from Dutch sentences permits the derivation of semantic structures that match English recognition sentences more readily than the converse. No explanation of these results is attempted here, particularly as there was not Dutch acquisition - Dutch recognition control condition. Experiment 4 results support the findings in the previous three studies and extends the experimental base upon which the interpretation of an abstract conceptual code was first formulated.

The present approach to conceptual abstraction must be supplemented by a well developed, psychologically valid system for expressing semantic representations. Thus 'thought' is a name given to a phenomenon whose properties are explicated or described, in the first instance, by such a semantic representation. Whereas the nature of such a representation remains to be formulated, it is empirically the case that its structure must move beyond the sentence and must be sufficient to encompass the knowledge of semantically related sets of events. From a psychological perspective it would seem that the 'rich language' descriptions of such conceptual structures, including both linguistic and extra-linguistic knowledge, as proposed by Schank & Quillian are most likely to eventually converge with the experimental findings from research on the abstraction and memory of ideas.

Nevertheless, semantic descriptions of memory representations are only the first step towards the specification of a functioning abstract conceptual system in human information processing. The preliminary results of the present research provide evidence that both the visual and auditory mode are equally adept in processing sentential information (see Freides, 1974). Similarly, the present research suggests that variation in the informational quality or form of the ideas expressed within either the visual or auditory mode has little effect on the construction and subsequent utilization of the information in another form. Thus it is quite remarkable that *S*s were able to constructively integrate information from pictures and sentences and perform in recognition memory on sentences and pictures respectively, as if the information was embodied in the same form. Similarly remarkable, even if intuitively more acceptable, bilingual *S*s were able to process information as readily from English to Dutch as from Dutch to English.

These findings strongly suggest that while there may be certain modality preferences for certain kinds of information (for example, the visual modality with respect to form), when processing full blown propositional material using the present paradigm, sensory modality is of little consequence (see Gibson, 1969). Nevertheless, cross-modal studies using propositional information loads are required. In addition, the present research lacked several control conditions. Thus both Experiment 3 and 4 required a picture acquisition - picture recognition and a Dutch acquisition - Dutch recognition condition respectively, in order to properly evaluate the results. Furthermore, the present paradigm may not be sufficiently sensitive to detect the effects of informational quality or form, of age related performance, of auditory or visual deficient populations and still other conditions. However, it would be quite feasible to adapt the present paradigm and incorporate the more sensitive forced choice procedure in recognition and employ a reaction time measure in addition to recognition confidence ratings.

The present research on conceptual abstraction has a number of implications for practise. Assuming the psychological validity of the constructive integration of ideas, the issue to emerge most forcefully concerns the optimal manner in which to communicate semantic information. That is, what kinds of syntactic structures and prosodic forms are most effective and efficient in the communication of ideas. Presumably answers to these questions can be obtained only relative to a description of the complexity of the semantic import of linguistic structures. Thus an increase in syntactic complexity may facilitate comprehension by facilitating the constructive integration of new information with existing knowledge.

This approach to conceptual abstraction urges the differentiation of various levels of comprehension or understanding. Obviously, understanding is both a function of the information conveyed by the stimulus designs, whether linguistic or a-linguistic, and existing knowledge in memory. Effective communication and understanding depends upon the 'shared' knowledge that the communicants can bring to bear upon the demands of the context. The construal of meaning is a radical synthetic activity which involves conceptual abstraction and never the mere registration and storage of particular events.

Footnotes

1. The author is grateful to Dr. Frank Kessel for making available the unpublished writings of Dr. John Bransford and Dr. Jeffry J. Franks (1970) which were essential to the development of the following two chapters.
2. A complete description of the procedures employed in the Bransford and Franks paradigm are available in Chapter 7.
3. In fact Anderson & Bower (1973) maintain that the determination of intersecting contexts in the precise manner indicated in the text (p. 163, this thesis) would not result in the "linear effect"; this result obtains only if *S*s resort to a context counting strategy.
4. The author is grateful to Ms. Donna DeCarlo for the fine illustrations employed in Experiment 3.

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Appendix A

The four theme sentences and one complete set of derived sentences from theme 1, in Experiment 1.

Theme 1. The warm breeze blowing from the sea stirred the heavy evening air.

Theme 2. The old man resting on the couch is reading the story in the newspaper.

Theme 3. The ants in the kitchen ate the sweet jelly which was on the table.

Theme 4. The rock which rolled down the mountain crushed the tiny hut at the edge of the woods.

Theme 1. The warm breeze blowing from the sea stirred the heavy evening air. (FOUR)

The warm breeze stirred the heavy evening air. (THREE

The warm breeze blowing from the sea stirred the evening air. (THREE)

The breeze blowing from the sea stirred the heavy evening air. (THREE)

The breeze stirred the heavy evening air. (TWO)

The breeze blowing from the sea stirred the evening air. (TWO)

The warm breeze was blowing from the sea. (TWO)

The warm breeze stirred the evening air. (TWO)

The breeze was warm . (ONE)

The evening air was heavy. (ONE)

The breeze stirred the evening air. (ONE)

The breeze was blowing from the sea. (ONE)

Appendix B

The set of non-case sentences employed in the recognition list of Experiment 1.

1. The old man in the tiny hut by the sea ate the sweet jelly.
2. The newspaper was on the table in the kitchen in the tiny hut.
3. The warm breeze blowing down the mountain stirred the old man.
4. The old man rolled the rock down the mountain.
5. The old man at the edge of the woods felt the evening air blowing from the sea.
6. The man sat at the table in the hut by the sea reading the story.

Appendix C

The set of ordered sentences in the two acquisition lists employed in Experiment 1.

Acquisition list 1.

The ants were in the kitchen.

The rock which rolled down the mountain crushed the hut at the edge of the woods.

The breeze stirred the heavy evening air.

The story was in the newspaper.

The hut was at the edge of the woods.

The warm breeze blowing from the sea stirred the heavy evening air.

The old man is reading the story.

The ants ate the sweet jelly which was on the table.

The breeze was blowing from the sea.

The rock crushed the tiny hut.

The sweet jelly was on the table.

The old man resting on the couch is reading the story.

The warm breeze stirred the heavy evening air.

The ants in the kitchen ate the sweet jelly which was on the table.

The man was resting on the couch.

The tiny hut was at the edge of the woods.

The breeze stirred the evening air.

The ants in the kitchen ate the jelly.

The rock crushed the tiny hut at the edge of the woods.

The man is reading the story in the newspaper.

The hut was tiny.

The ants ate the jelly.

The man resting on the couch is reading the story in the newspaper.

The warm breeze was blowing from the sea.

Acquisition list 2.

The jelly was sweet.

The rock which rolled down the mountain crushed the tiny hut.

The breeze blowing from the sea stirred the evening air.

The man is reading the story.

The rock rolled down the mountain.

The breeze blowing from the sea stirred the heavy evening air.

The old man was resting on the couch.

The ants in the kitchen ate the jelly which was on the table.

The evening air was heavy.

The rock which rolled down the mountain crushed the tiny but at the edge of the woods.

The ants ate the jelly which was on the table.

The old man is reading the story in the newspaper.

The warm breeze stirred the evening air.

The jelly was on the table.

The man resting on the couch is reading the story.

The rock which rolled down the mountain crushed the hut.

The breeze was warm.

The ants in the kitchen ate the sweet jelly.

The rock crushed the hut at the edge of the woods.

The old man on the couch is reading the story in the newspaper

The rock crushed the hut at the edge of the woods.

The man was old.

The ants ate the sweet jelly.

The warm breeze blowing from the sea stirred the evening air.

Appendix D

The four theme sentences and one complete set of derived sentences from theme 1, Experiment 2.

Theme 1. The murky ideas which were a product of naivete gave way to large scale rebuttals.

Theme 2. The incompetent maneuvers by foreign espionage precluded effective retaliation.

Theme 3. The arrogant attitude expressed in the speech led to immediate criticism.

Theme 4. The elated mood resulted in disorganized action which reflected stupidity.

Theme 1. The murky ideas which were a product of naivete gave way to large scale rebuttals. (FOUR)

The murky ideas which were a product of naivete gave way to rebuttals. (THREE)

The ideas which were a product of naivete gave way to large scale rebuttals. (THREE)

The murky ideas gave way to large scale rebuttals. (THREE)

The murky ideas were a product of naivete. (TWO)

The murky ideas gave way to rebuttals. (TWO)

The ideas gave way to large scale rebuttals. (TWO)

The ideas which were a product of naivete gave way to rebuttals. (TWO)

The rebuttals were on large scale. (ONE)

The ideas were a product of naivete. (ONE)

The ideas were murky. (ONE)

The ideas gave way to rebuttals. (ONE)

Appendix E

The four theme sentences and one complete set of derived sentences from theme 1, Experiment 3.

Theme 1. The football is in the square box on the round table in the brick house.

Theme 2. The bent key is on the oval ring in the right hand of the fat man.

Theme 3. The black bird is in the wire cage on top of the wooden box in the pet shop.

Theme 4. The bearded man is inside the tiny shelter under a palm tree on a desert island.

Theme 1. The football is in the square box on the round table in the brick house. (FOUR)

The football is in the square box on the round table. (THREE)

The square box is on the round table in the brick house. (THREE)

The football is in the square box. (TWO)

The square box is on the round table. (TWO)

The round table is in the brick house. (TWO)

The ball is a football. (ONE)

The box is a square box. (ONE)

The table is a round table. (ONE)

The house is a brick house. (ONE)

Appendix F

The complete set of pen drawings (ideas) belonging to a single theme as employed in Experiment 3.

The man is bearded.

The shelter is tiny.

The tree is a palm tree.

The island is a desert island.

The bearded man is inside the tiny shelter.

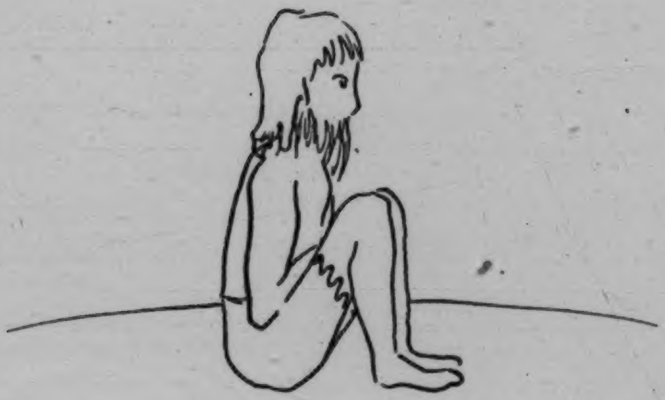
The tiny shelter is under a palm tree.

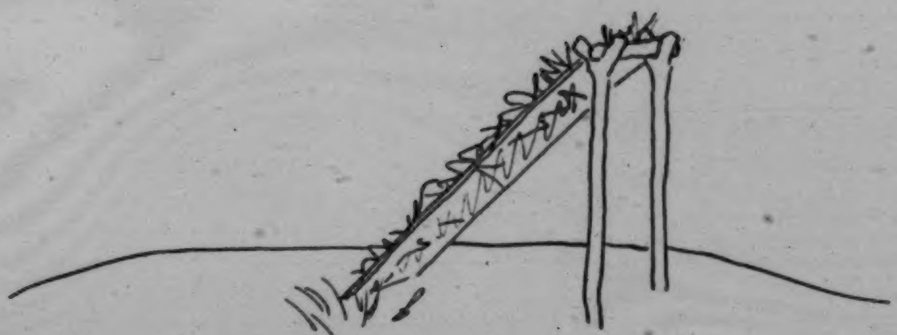
The palm tree is on a desert island.

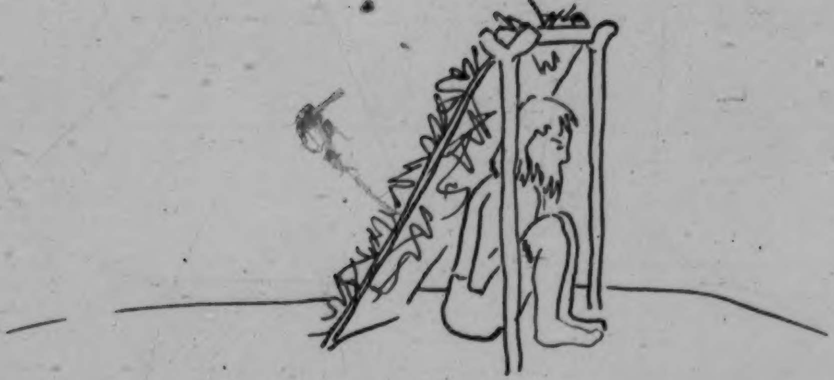
The bearded man is inside the tiny shelter under a palm tree.

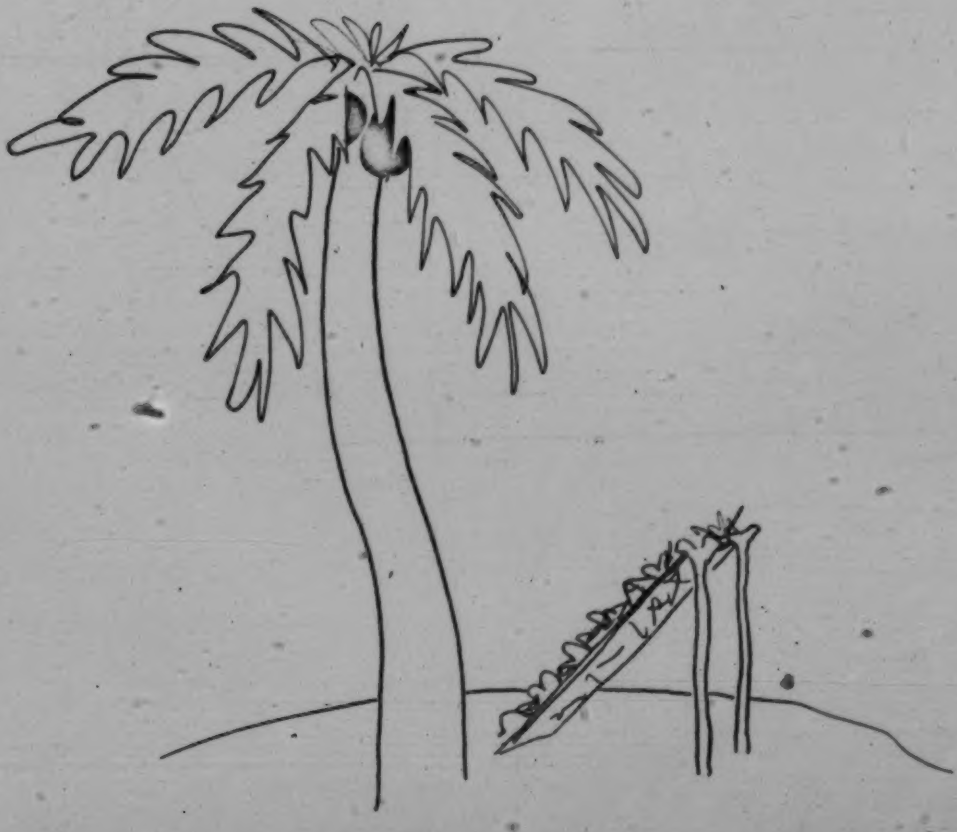
The tiny shelter is under a palm tree on a desert island.

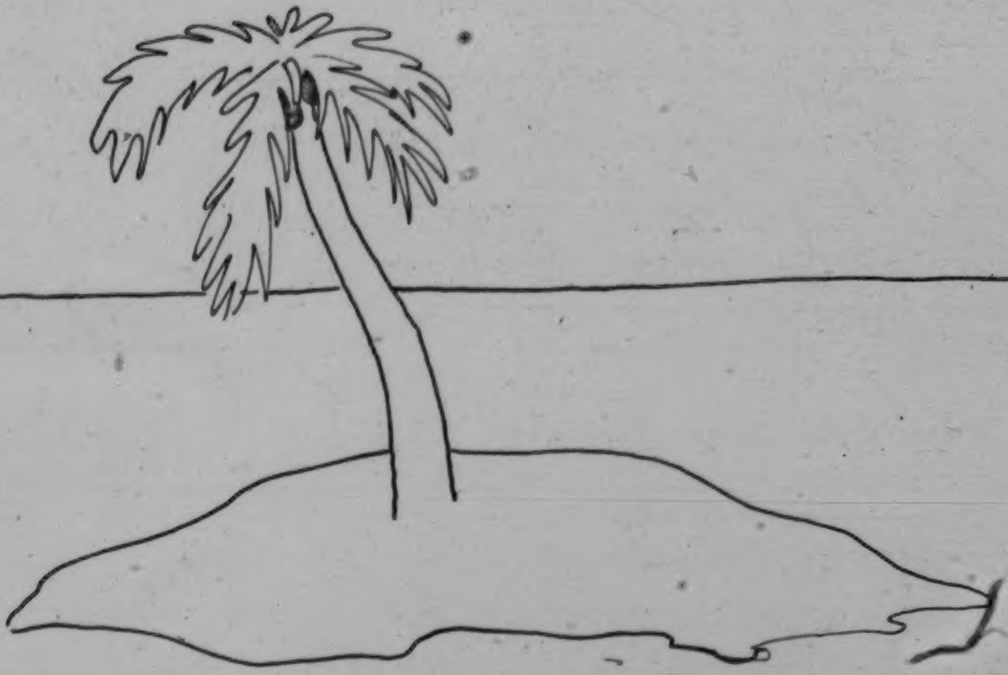
The bearded man is inside the tiny shelter under a palm tree on a desert island.

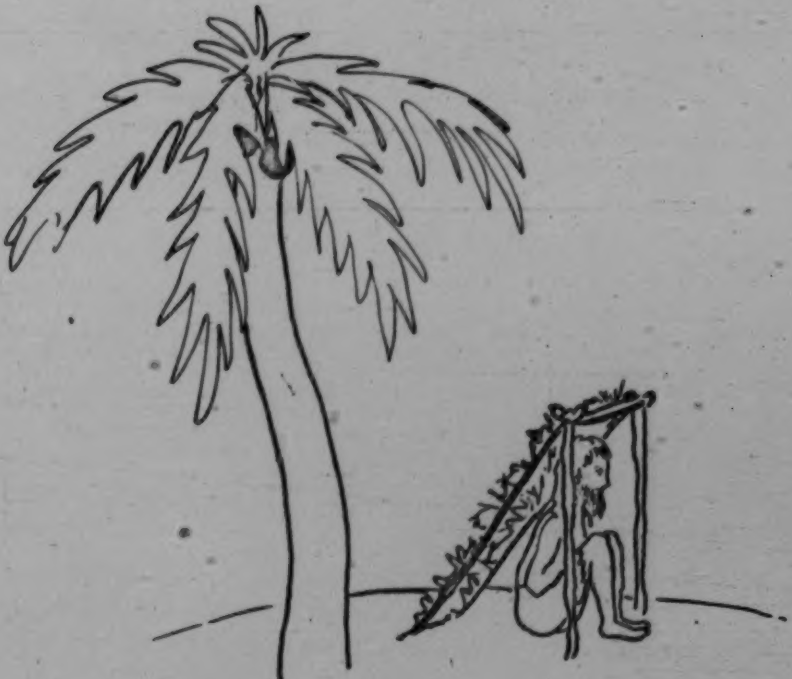


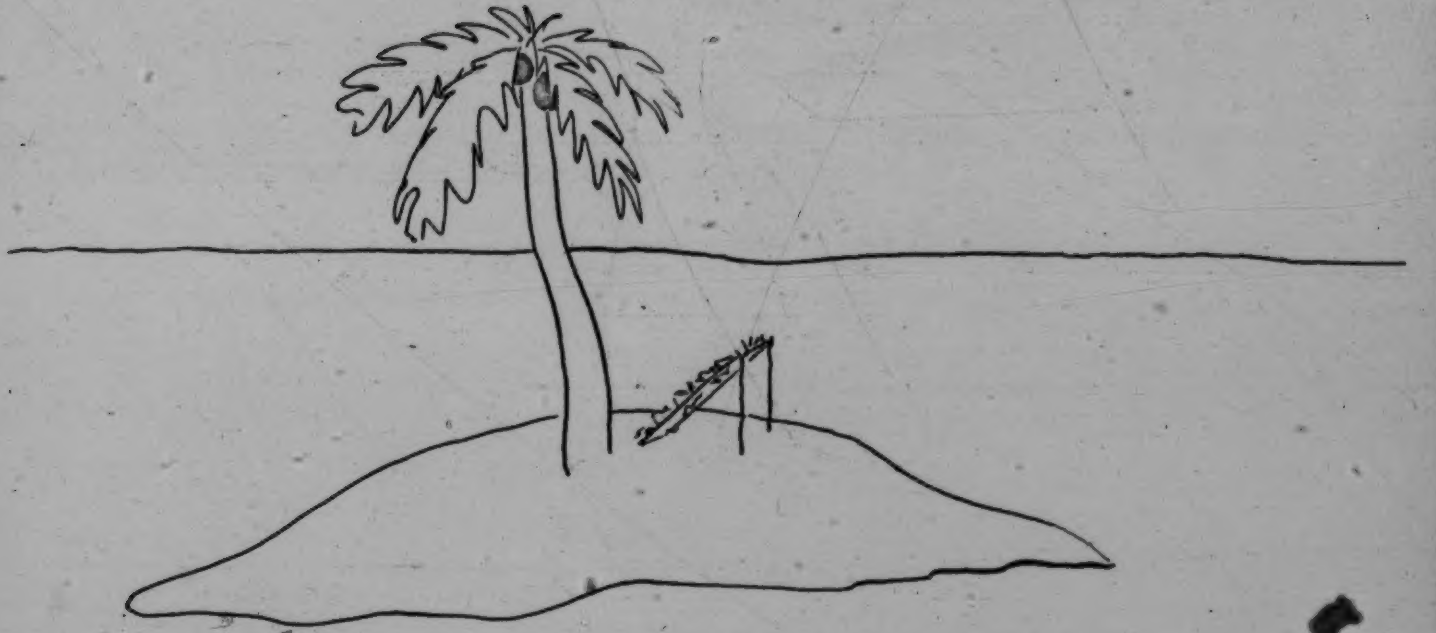


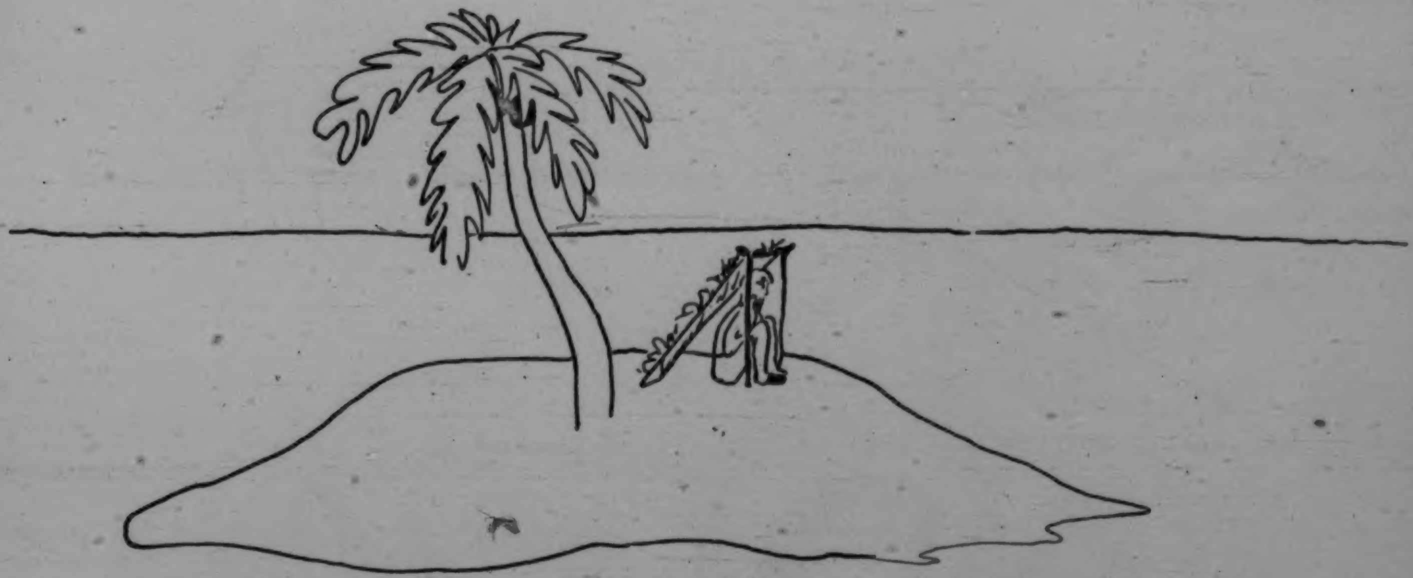












Appendix G

The set of ordered sentences in the two acquisition lists employed in Experiment 3.

Acquisition list 1

The key is bent.

The round table is inside the brick house.

The bearded man inside the tiny shelter is under a palm tree.

The bird is black.

The football is in the square box on the round table.

The palm tree is on a desert island.

The ring is oval.

The black bird is in the wire cage on top of the wooden crate.

The tiny shelter is under a palm tree.

The hand is the right hand of the fat man.

The square box is on the round table.

The wooden crate is in the pet shop.

The ball is a football.

The shelter is tiny.

The wire cage is on top of the wooden crate.

The oval ring is in the right hand.

The box is square.

The bent key is on the oval ring in the right hand.

The man is bearded.

The cage is a wire cage.

Acquisition list 2.

The table is round.

The bearded man is inside the tiny shelter under the palm tree.

The round table is in the brick house.

The hand is the right hand.

The wire cate is on top of the wooden crate.

The tree is a palm tree.

The oval ring is in the right hand.

The black bird is in the wire cage.

The square box is on the round table.

The bearded man is inside the tiny shelter.

The crate is a wooden crate.

The island is a desert island.

The bent key is on the oval ring in the right hand.

The football is in the square box on the round table.

The shop is a pet shop.

The tiny shelter is under the palm tree.

The black bird is in the wire cage on top of the wooden box.

The right hand is the hand of the fat man.

The house is a brick house.

The man is fat.

Appendix H

The four theme sentences and one complete set of derived sentences from theme 1, in the Dutch language, in Experiment 4.

Theme 1. Het warme windje dat van uit de zee waaide bracht de zwaare avondlucht in beweging.

Theme 2. De oude man die lag to rusten op de bank leest het verhaal in de krant.

Theme 3. De mieren in de keuken aten de zoete gelei die op de tafel stond.

Theme 4. De rots die van de berg rolde verpletterde de kleine hut aan de grens van het bosch.

Theme 1. Het warme windje dat van uit de zee waaide bracht de zwaare avondlucht in beweging. (FOUR)

Het windje dat van uit de zee waaide bracht de zwaare avondlucht in beweging. (THREE)

Het warme windje dat van uit de zee waaide bracht de avondlucht in beweging. (THREE)

Het warme windje bracht de zwaare avondlucht in beweging. (THREE)

Het warme windje waaide van uit de zee. (TWO)

Het warme windje bracht de avondlucht in beweging. (TWO)

Het windje bracht de zwaare avondlucht in beweging. (TWO)

Het windje dat van uit de zee waaide bracht de avondlucht in beweging. (TWO)

Het windje waaide van uit de zee. (ONE)

De avondlucht was zwaar. (ONE)

Het windje was warm. (ONE)

Het windje bracht de avondlucht in beweging. (ONE)

Appendix I

Figure 10. Recognition confidence ratings as a function of Sentence Length collapsed over Modes of Presentation in Experiments 1, 2, 3, 4.

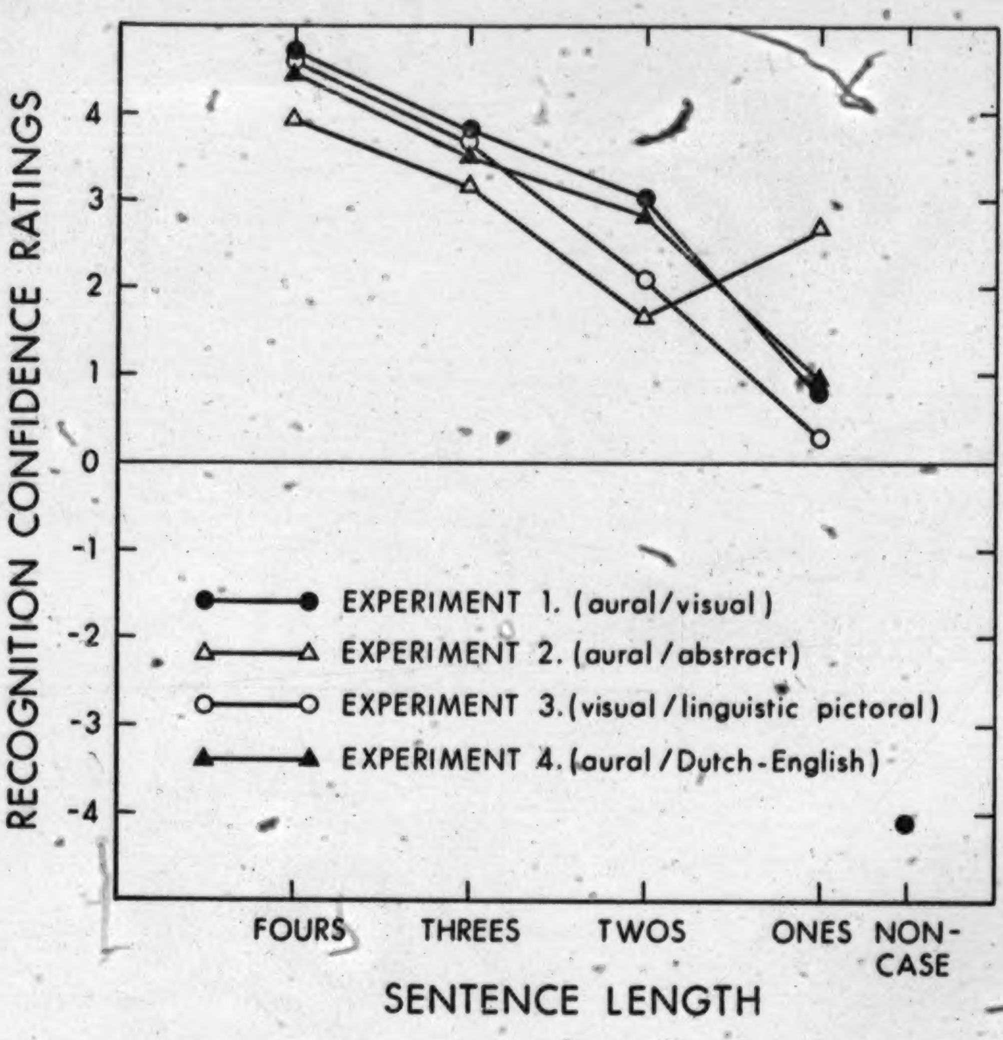


Figure 11. Recognition confidence ratings for the Old/New Sentences x Sentence Length interaction in the visual mode of presentation (Bransford & Franks, 1971; Mos, Exp. 1.). Recognition confidence ratings as a function of Sentence Length in the visual mode of presentation (Katz, 1973).

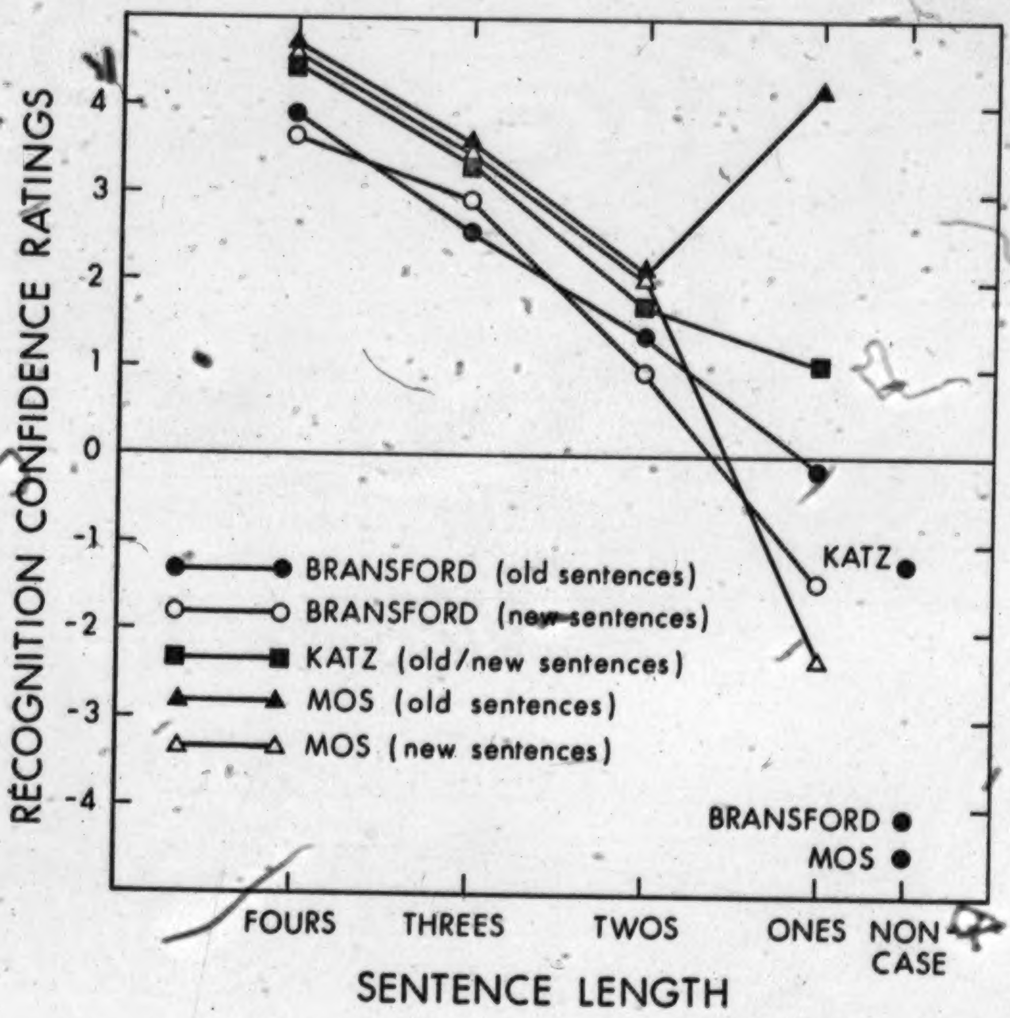


Figure 12. Recognition confidence ratings for the Old/New Sentences x Sentence Length interaction in the visual mode of presentation (Bransford & Franks, 1971), and the aural mode of presentation (Mos, Exp. 1.)

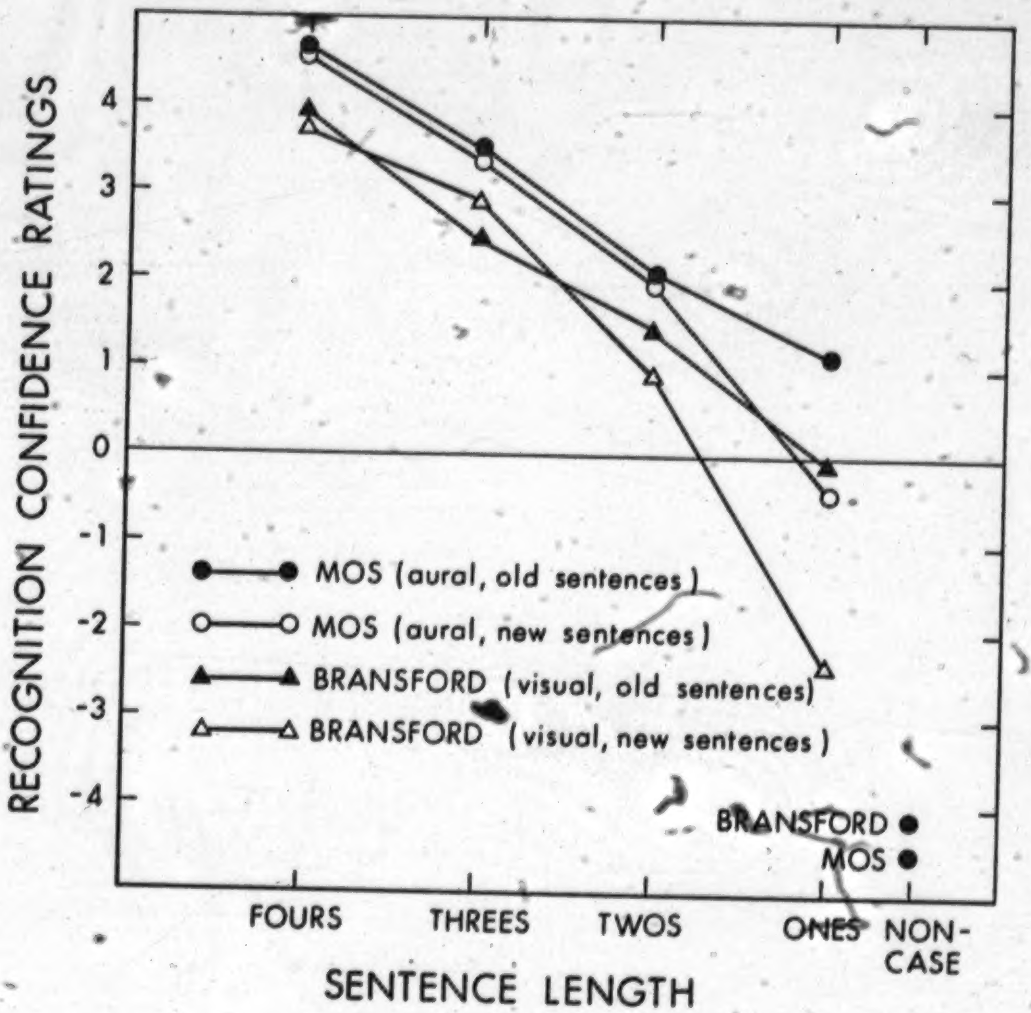


Figure 13. Recognition confidence ratings for the Old/New Sentences x Sentence Length interaction (Reitman & Bower, 1973; Mos, Exp. 1, visual mode).

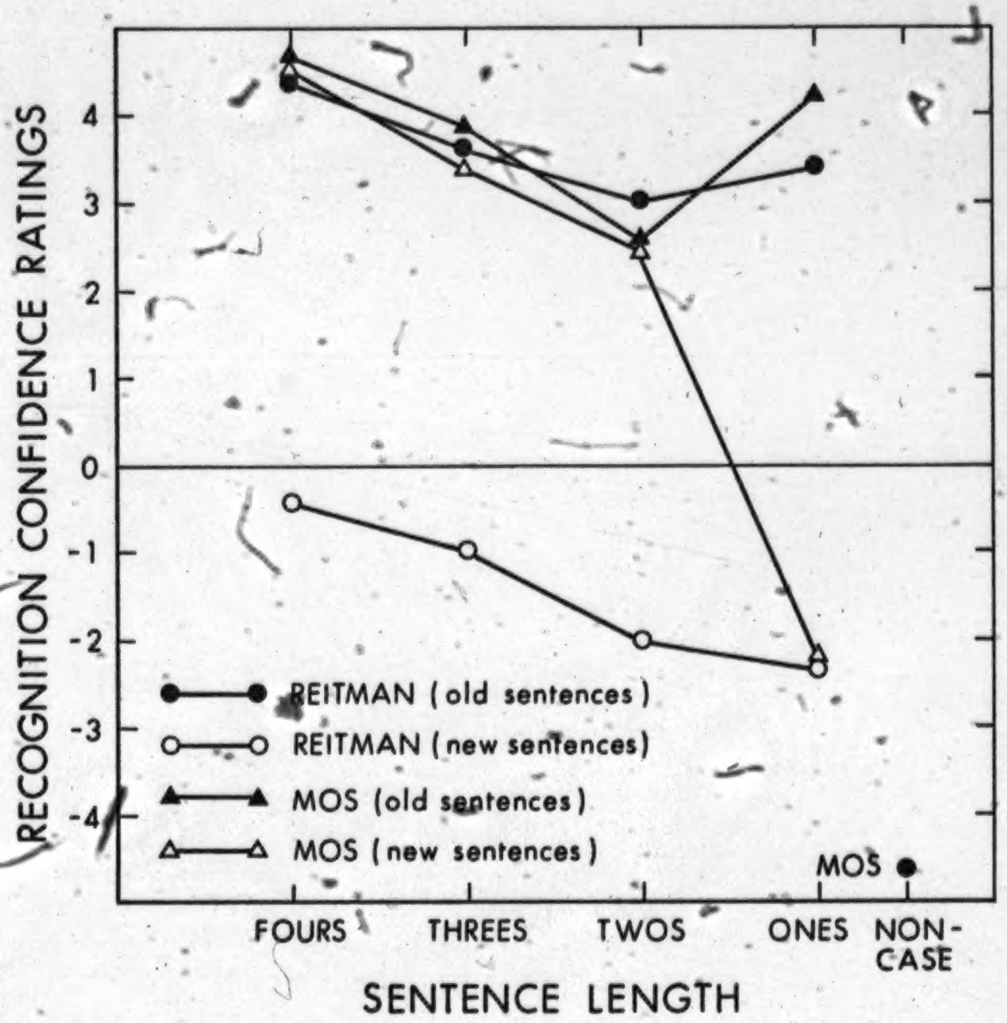


Figure 14. Recognition confidence ratings as a function of Sentence Length using abstract sentences (Bransford & Franks, 1973; Mos, Exp. 2.).

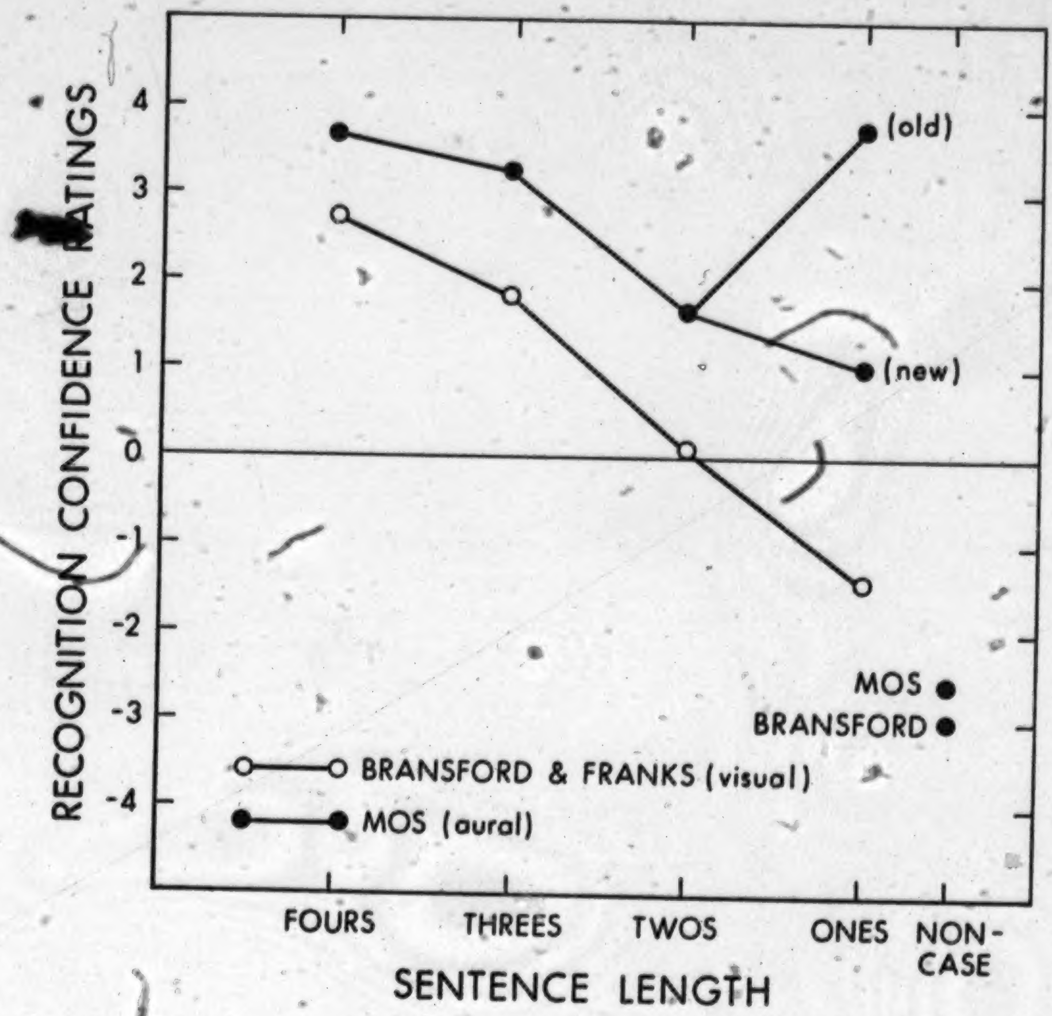


Figure 15. Recognition confidence ratings as a function of Sentence Length (Experiment 1, visual mode), and as a function of Picture Complexity and Sentence Length (Experiment 3, visual mode).

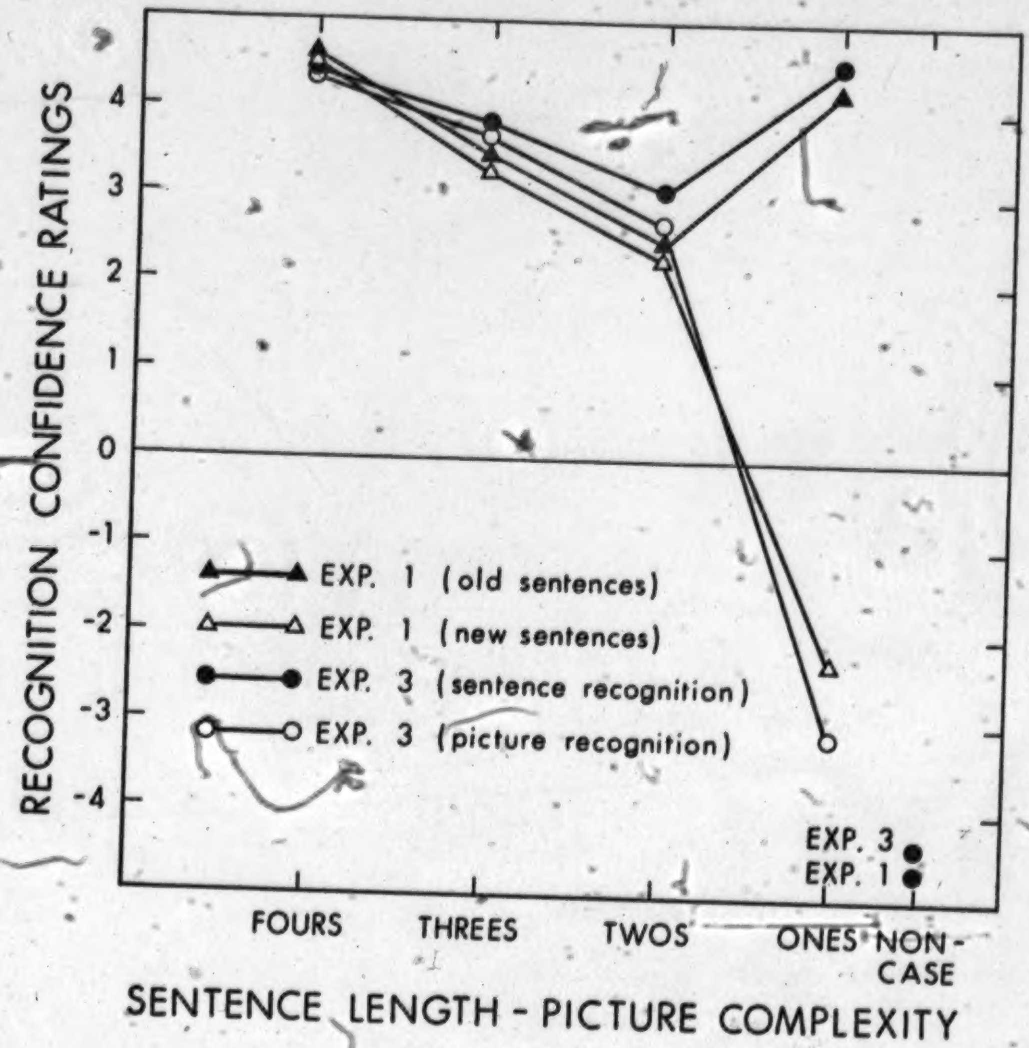


Figure 16. Recognition confidence ratings as a function of Sentence Length in Experiment 3 (sentence/picture recognition), and Experiment 4 (Dutch/English recognition).

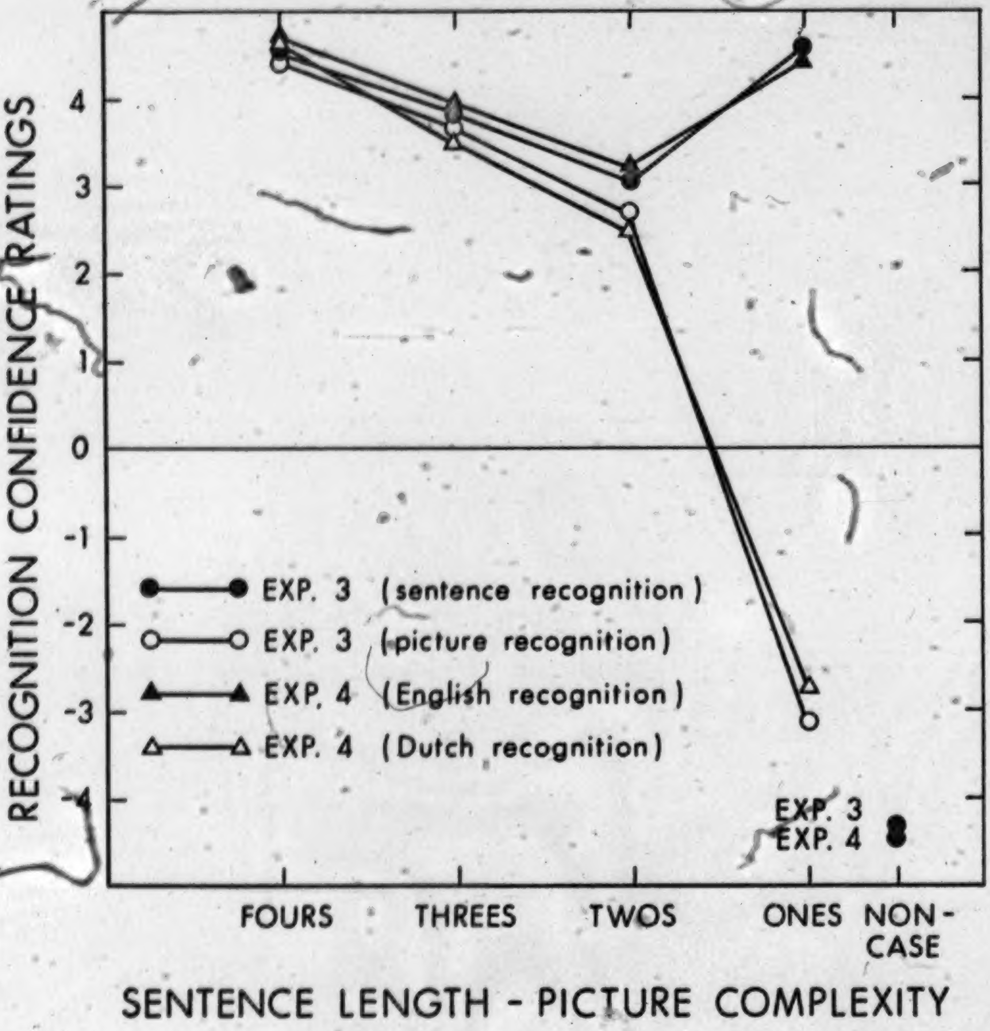


Figure 17. Recognition confidence ratings as a function of Sentence Length (Experiment 1, old and new sentences in the aural mode) and Experiment 4 (Dutch and English recognition in the aural mode).